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PREVIEW OF THE ELECTRONIC COMPONENTS CONFERENCE/143

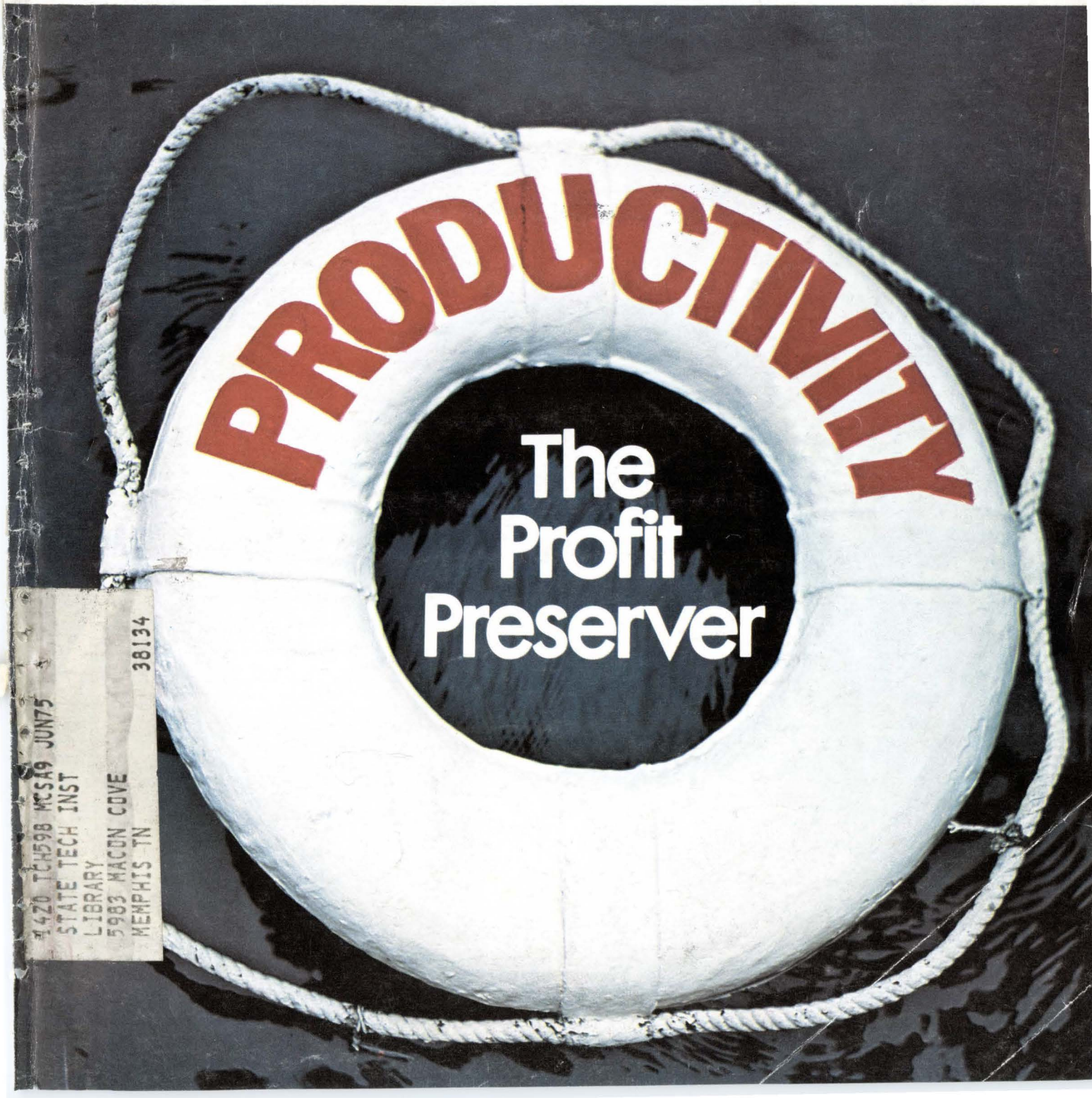
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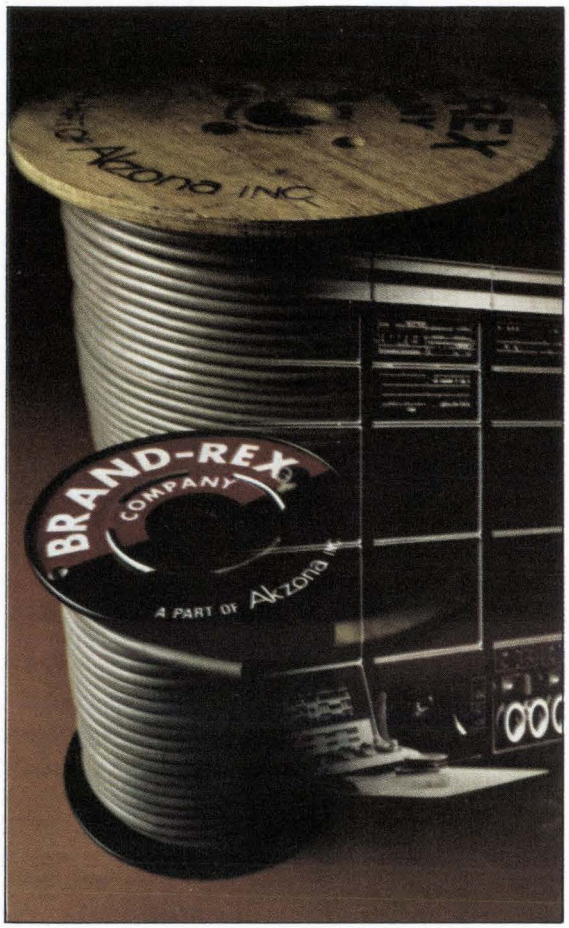
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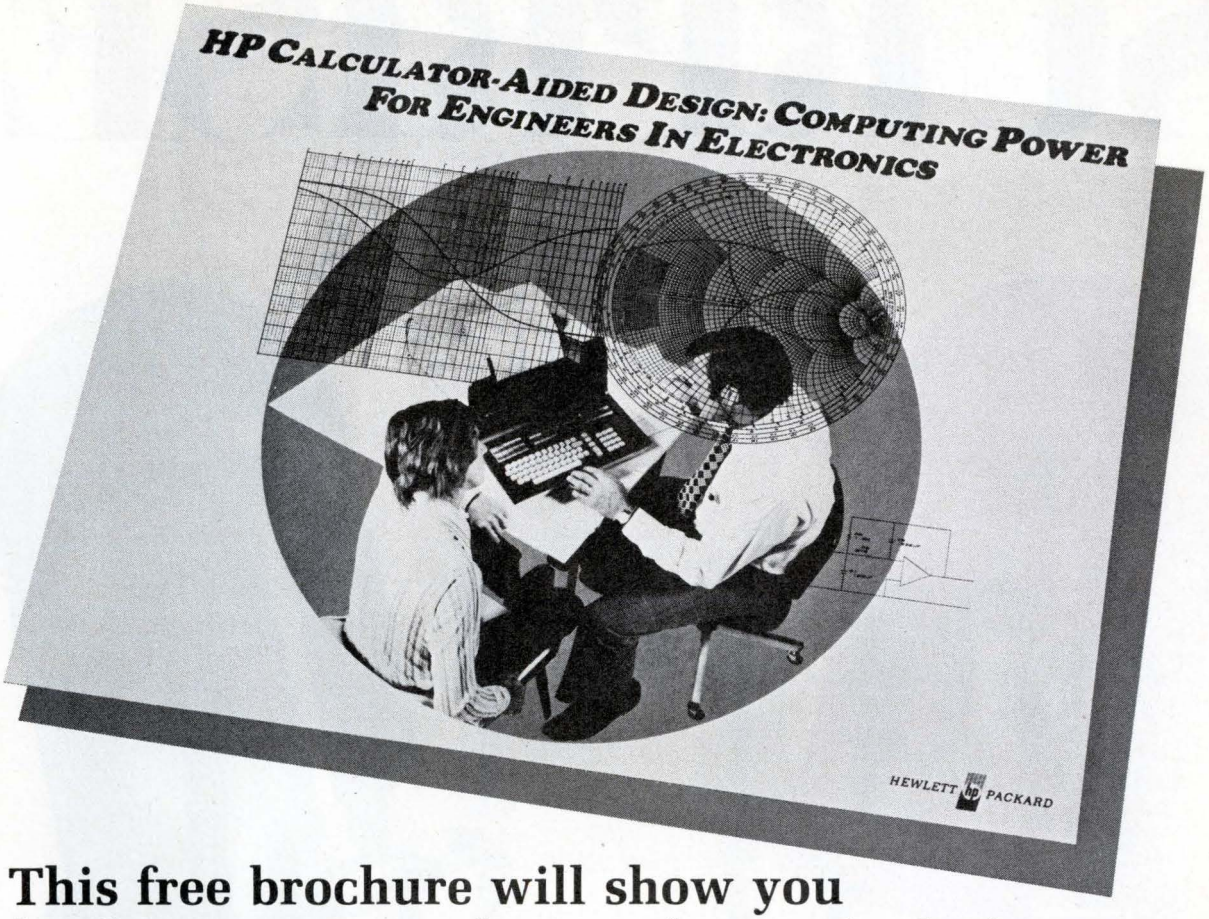
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Highlights

Cover: Productivity—the way to keep afloat, 89
The best way that electronics companies can weather a rough economy and a tough international marketplace is by boosting their output per man-hour. This special issue on productivity discusses how automation (p.95), motivation (p.111), design engineering (p.123), management (p.133), and the Government (p.139) can help. Cover photograph is by Ed Lada.

Where Fairchild is heading and why, 65
The president of Fairchild Camera & Instrument Corp. explains how he hopes his company will succeed with various new (and not-so-new) semiconductor technologies and devices. This is one of a series of interviews with the chief executive officers of leading electronics companies.

Components conference has wider scope, 143
Design engineers attending the 25th Electronic Components Conference in Washington next month will learn how medium- and large-scale integration is expanding the potential of hybrid circuits and extending the capacities of other component technologies.

Components show has doubled in size, 153
Simultaneously with the components conference, manufacturers from a cross section of the industry will be displaying their products. Among the more significant previewed here are a membrane keyboard switch and a variable chip inductor.

And in the next issue . . .
Preview of the National Computer Conference . . . exploring the data domain . . . high-density magnetic tape in a recording system for computer storage.

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Publisher's letter

Productivity has a special meaning for the electronics industries. One of the key strengths of electronics has been the high level of productivity shown by the leading electronic-product manufacturers. That level of productivity not only gives electronics an edge when competing with companies in other technologies, but it points the way to a broadening market for electronic wares. That's why we have devoted the major part of an issue of *Electronics* to that theme.

It may well be asked why we decided to do a detailed survey of productivity at a time when the nation's economy is in such poor shape. The answer is simple. While in no way belittling current problems—and, what with staff cuts, delays in capital investment, and slashings of R&D funds, they are severe—our goal was to look ahead. An economic turnaround is coming, and the company that makes plans now will be ready when it comes.

As we say in the special report, which starts on page 89, "Key managers and management consultants interviewed by *Electronics* editors stress that those companies that continue to improve their product and boost productivity at the same time are the companies that will emerge from the recession on top."

Productivity is a worldwide concern, and, so, our special report is based on worldwide inputs. Working with on-the spot reports from our news bureaus around the country, in Europe, and in Japan, an editorial team in New York prepared the final report. Executive editor Sam Weber, associate editor Jerry Walker, and senior editors Steve Scrupski and Larry Altman spearheaded the team.

The 42-page report gives a wide-ranging view of the many facets of productivity. Organized into five major segments, the report first looks at the question of automation (see p. 95). Then come sections on employee motivation (p. 111), designing for productivity (p. 123), streamlining management (p. 133), and Washington's so-far-reluctant role (p. 139).

As can be seen from that quick summary, the subject is not limited to machinery or technology. The focus, really, is on people. When all is said and done, productivity is a function of the output per worker, and the thrust of our presentation is on increasing that output, not on replacing workers with machines. What's more, the design and redesign of products and processes for improved productivity adds a challenging new dimension to the engineer's job.

There's much grist for long-range planning and a lot of thought-provoking material in our productivity report. The case studies we present on how some companies successfully moved toward increased productivity should be especially valuable. We will continue to cover the subject in the issues and years to come, and we welcome any concrete suggestions or comments from our readers.



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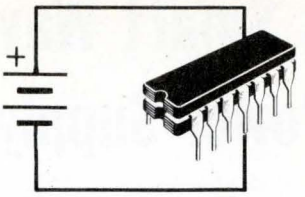
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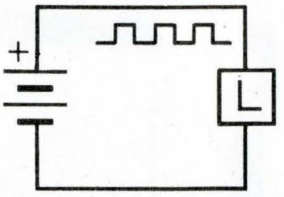
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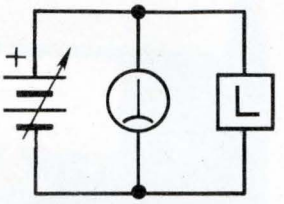
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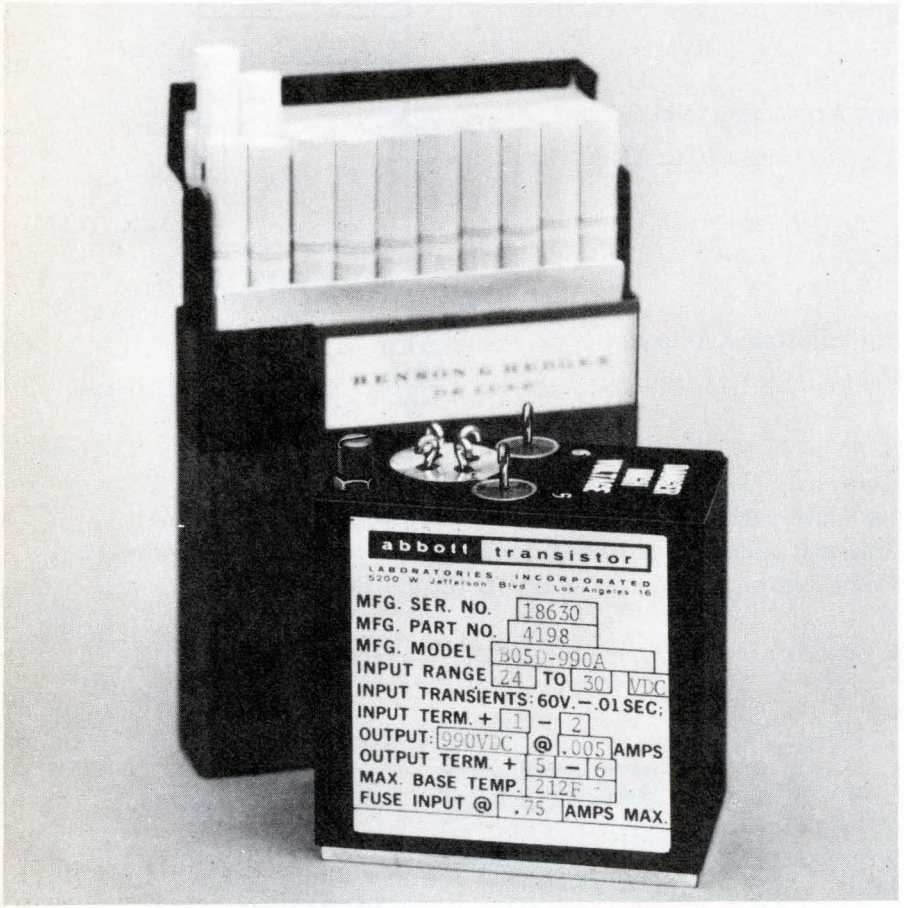
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Readers comment

The Brooklyn Bridge?

To the Editor: I have had much pleasure in reading the item which describes a method of using a cooled shell in superheating certain materials [*Electronics*, Jan. 23, p. 32]. To me, it sounds like the best example of selling the Brooklyn Bridge that I have heard in years.

When I was a schoolboy some 40 years ago I was taught that it was common practice, when electrolyzing materials, to cool the containing crucible so as to protect it with a solid-state layer of the material being heated. The same was true in electrolyzing fluorides to obtain fluorine, a hard-to-manage gas.

So, before discovering novelties, it would be safer to ask old timers; they may have already heard of it. Moreover, when a novelty comes from Russia, you can bet it is 30 to 50 years old anywhere else.

Alain Le Solleuz
Electronique Générale
Brest, France

Editor's reply: *We asked the president of Intermat Corp., the company that is producing the so-called "skull" furnace in the U.S., for a response to the above, and here it is:*

First of all, to avoid any confusion, the skull-melting system described in the article has been developed primarily for the melting of a wide variety of refractory oxides such as zirconia (zirconium dioxide, not metallic "zirconium" as noted in the article).

While, admittedly, it is increasingly difficult to invent anything truly unique these days, I trust that those who are knowledgeable in the field of materials technology will recognize the impact of this new skull-melting technique in alleviating the problems of working with refractory oxides having melting points well beyond 2,000°C.

Further, as an "old timer" (in the field of crystal growth) I've learned that most broad generalizations regarding the validity of technology as it exists in any part of the world are, in most cases, suspect.

Joseph F. Wenckus
Cambridge, Mass.

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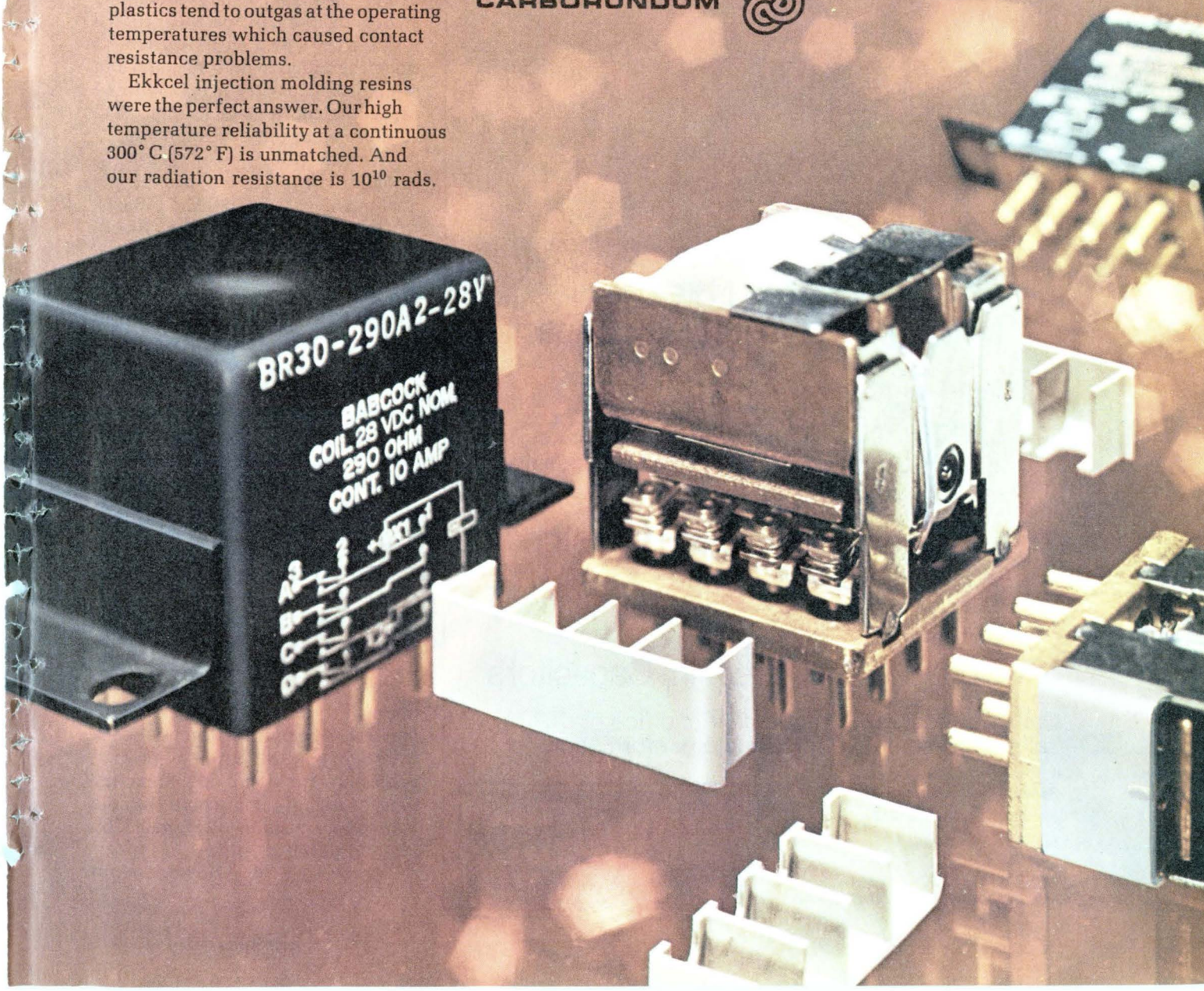
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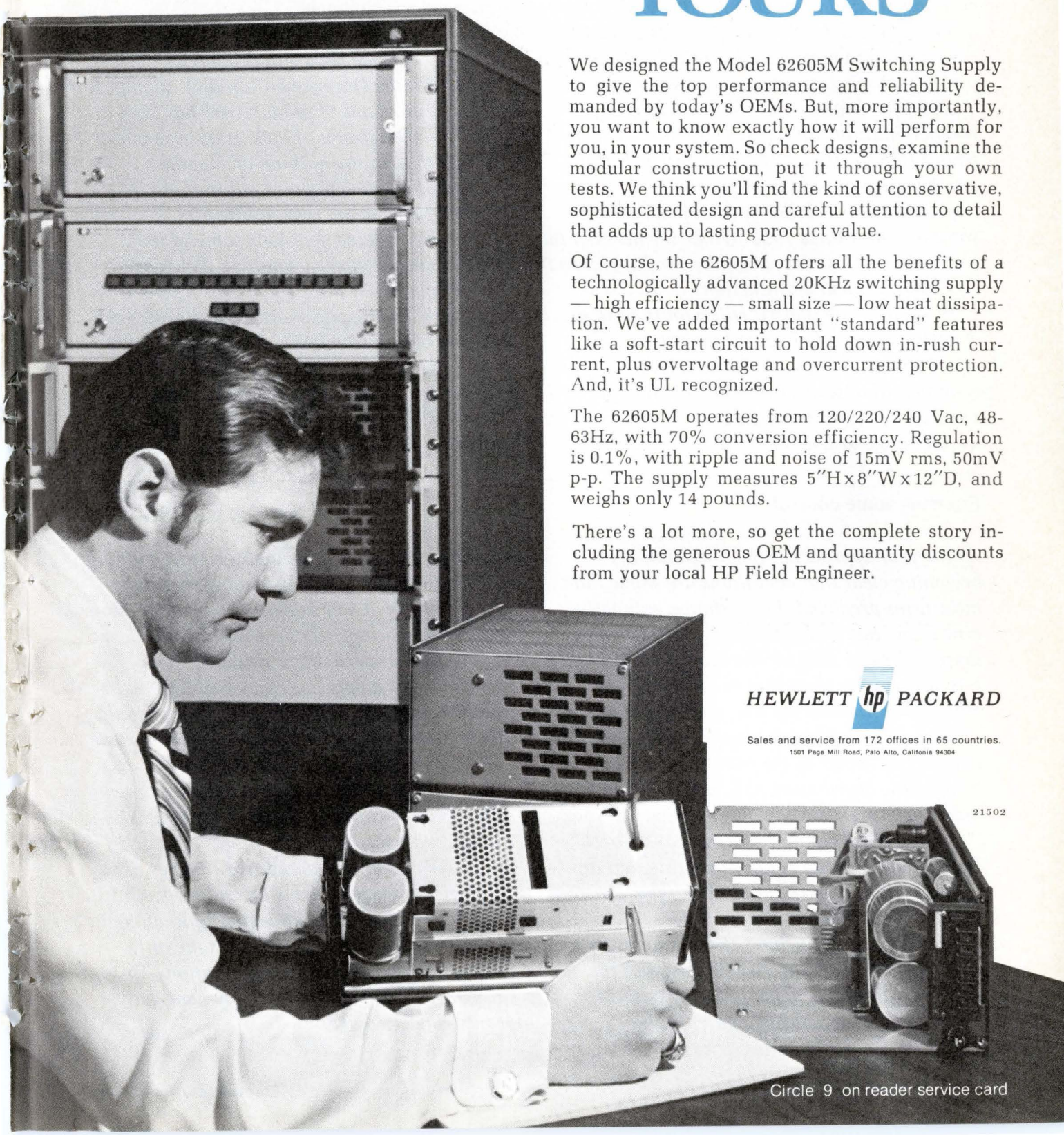
■ A circuit that corrects time-base errors caused by variations in video recorder tape drives [March 7, 1974, p. 31] appears to have found its niche. The circuit, a serial analog memory developed by Reticon Corp. of Mountain View, Calif., is called SAM 64. It utilizes self-scan MOS imaging instead of the charge-coupled-device delay-line approach. John Rado, Reticon's president, says SAM 64 is in full-scale production and the company has sold thousands of units. Rado says that in the past year three related products have been introduced, all selling for about $100 in prototype orders and $20 to $25 in volume. They are the SAM 128 (128-element serial analog memory); SAD 100 (serial analog delay); and the TAD 12 (tapped analog delay). As for the original SAM, it uses two shift registers to clock the video signal into and out of an MOS capacitor array. With 64 capacitors and a clock rate of up to 10 megahertz, the device provides a maximum delay of 6.4 microseconds. The TV raster scans a line in about 63 μs, so one SAM can correct time-base errors of up to 10% of the line width.

■ Signetics a year ago was about to become the first major American semiconductor maker to announce a CCD memory product [March 7, 1974, p. 26]. Due in the last quarter of 1974, the 16,384-bit dynamic shift register was destined to replace disk and drum memories at a cost of 0.1 cent a bit and a speed of 20 megahertz—compared to the 3 to 5 MHz of shift registers. But now Signetics has put off its plans. Jack Halter, marketing vice president, says, "Efforts are still in progress," but the company is not yet ready to introduce anything. What's more, Halter says he doesn't know if the introduction will come within 1975. He adds that more important things—like a 4,096-bit RAM and a microprocessor—are occupying Signetics' time. Among them could be the planned acquisition of Signetics by Philips [March 20, p. 38].

—Howard Wolff

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Editorial

The challenge of productivity

The electronics industries can justifiably claim leadership both in improving its own productivity and in spreading advanced technology to solve problems. At the same time, electronics products have historically declined in price thanks in large part to design efficiency.

Thus, for example, in 20 years the cost per 100,000 multiplications by computer has gone from $1.26 to $0.01, according to IBM. Put another way, processor performance improvement per dollar of rental has gone up some 85 times since 1952. Other segments of the electronics industries can make similar claims in cost improvement per function.

In short, while there is still a lot to be done, electronics has a fine record in cost effectiveness. Now, with the nation in a serious economic slump, electronics companies are in a position to contribute to improving efficiency in a wide range of U.S. endeavors via automated systems, communications links, data-processing and word-processing programs, and energy-conservation equipment.

The simple truth is that other industries do not have the same record in productivity efforts. And, so far, the Government's major attempt to detail the problems of productivity has been an abject failure because of lack of governmental coordination, to say nothing of support.

Perhaps it's time to point out to those in Washington who are responsible for productivity-related decisions some of the impact of electronics technology. Perhaps it's time for the Electronics Industries Association to prepare a white paper—How electronics can improve U.S. productivity. Such an initiative would give Washington's economic planners a ready-made blueprint showing how the electronics business can help some of the other businesses in this country.

Exerting some control

As the year approaches the midpoint, it's becoming clear that conditions are worse than most firms predicted. For instance, estimates now show that total semiconductor sales may drop by 20% to 30% for the year—and business has been poorer than that in the first half. Although estimates put this year's military buying of semiconductors up 5%, the rest of the news is bad. Sales to the computer segment will be off 30%, distributors 35%, consumer 10% and industrial 15%.

On the other hand, the worst may be over. Some industry leaders are predicting that an upturn will start in the second half and are even preparing for a boom year in 1976.

But there's a disturbing element here. By now it's evident that inventory lead time was the major villain in the panic ordering in 1974. Over-enthusiastic end-equipment sales estimates, too, helped fuel an inventory buildup.

Therefore, it is really disturbing that along with glimmers of new business come predictions of possible shortages in some areas in the last half of 1975. Indeed, there could be some imbalances of supply, and they will have to be watched carefully. But talk of shortages could also be calculated to start another buying rush.

Perhaps these wild swings really are uncontrollable. Still, what's needed are fewer self-interested statements and more hard-headed, realistic appraisals of present market limits and potential market growth rates. And that kind of realism means an end to wishful thinking and the start of a meaningful dialogue between buyers and sellers. That's the only chance we have to bring these gyrations—in sales, inventory, capacity, employment and profits—under control.

Announcing the 2101.

And its high speed replacement.

There's a terrific little part that hasn't been out too long: The 2101. Whether you've heard about it or not, forget it. Now there's something twice as nice for the same price.

The Am9101. A 256x4-bit N-channel static RAM. Our slow one is twice as fast as their slow one. Our fast one is twice as fast as their fast one. Ours is easier to use, allows better margins, simpler timing and requires lots less power.

The Am9101 guarantees two full TTL loads at TTL voltages. That means increased flexibility, drive and noise immunity.

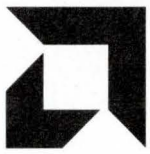
The Am9101 and its friends, the Am9111 and Am9112, come in 22 pins with separate inputs and outputs and 18 or 16 pins with common inputs and outputs.

If you only need 2101 performance, we make them too – plus, free with every order, MIL-STD-883.

Send for the family album. The Am9101. Another fond memory.

Parameter	9101	2101
Access Time/ Cycle Time	500 nsec 9XXXA 400 nsec 9XXXB 300 nsec 9XXXC 250 nsec 9XXXD	1000 nsec 2XXX 850 nsec 8XXX 650 nsec 2XXX-2 500 nsec 2XXX-1
Data Hold Time – t_{DH}	0	100 nsec
Write Recovery Time t_{WR} (Address Hold Time)	0	50 nsec
Address Setup Time (Write Delay) t_{AW}	0	150 nsec
Power Dissipation 5.25 V 0-70°C	9XLXX 173 mw 9XXX 289 mw	368 mw
Current Drain 5.25 V 0-70°C	9XLXX 33 mA 9XXX 55 mA	70 mA
Fan-out	2 T²L Loads	1.25 T²L Loads
V_{OL}	3.2 mA at 0.4 V	2.0 mA at 0.45 V
V_{OH}	2.4 V at 200 μA	2.2 V at 150 μA
V_{IL}	0.8 V	0.65 V
V_{IH}	2.0 V	2.2 V
Noise Immunity vs. TTL Forcing Function	Hi Level 400 mV Lo Level 400 mV	Hi Level 200 mV Lo Level 200 mV
DC Power-Down	V_{PD} =1.5 V I_{PD} =31 mA (47 mw)	NA

Advanced MOS/LSI



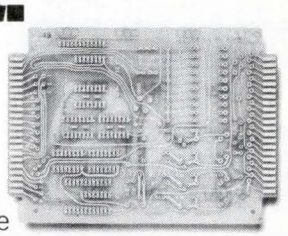
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YIELD


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In 1974 you probably didn't worry about it. In 1975 your job may depend on it.



Until now, it seemed that only people in the semiconductor industry cared about yield.

But now all that's changed.

With today's tight economy, everyone is worrying about yield. Because to raise yield is to raise profits. To ignore yield is to invite disaster.

The big question now is how to get the greatest yield per dollar invested. For the most profit.

The answer: Think Yield. Not just at the *end* of the production line, but right from the beginning. Because the most wasteful thing you can do is to add value to a bad part.

Looking at yield in this manner cuts costs two ways. It cuts labor costs, because the earlier a defect is detected, the cheaper it is to find. And it cuts equipment costs by simplifying the hardware requirements.

As the leading producer of semiconductor test equipment, we've long looked at the entire production process in terms of yield. Which is why we feel that any testing program that places the entire burden of quality on final testing alone is missing the point—the defects that drive yield down are of several totally different types, each requiring specialized attention.

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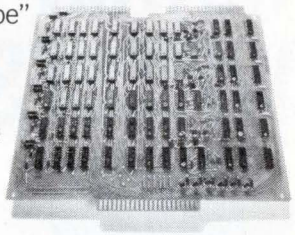
Let's look at the possibilities:

1. Incoming Inspection. It may be right to sample test. Or to 100% test. Whatever your yield needs are, we have a complete line of state-of-the-art inspection instruments and systems—for ICs, transistors, diodes, zeners, FETs, relays, capacitors, resistors, SCRs and thyristors.

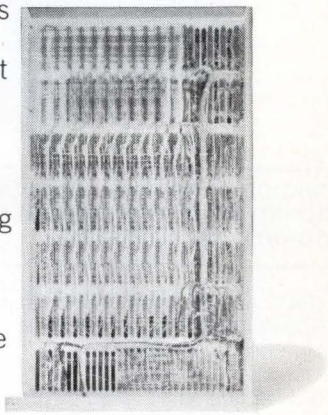


2. Bare-Board Testing. This depends on the value and complexity of your bare boards. Our solid-state-switched systems can test a board (even multilayer types) with several thousand points in seconds, identifying opens and shorts in the board's own nomenclature. We even offer mechanical fixturing for turnkey systems.

3. Loaded-Board Testing. Our circuit test systems with "guided-probe" troubleshooting allow technically unskilled operators to pinpoint errors quickly and reliably. This means you no longer need to use valuable technicians for chasing down routine soldering and insertion errors.



4. Backplane Testing. With only a fixture change, the same systems that test bare boards can also test backplanes, eliminating systems test problems caused by misserviced backplanes. Daisy-chained fixture cards make connection to the test system quick and easy.



Now which kinds of testing are best for you? That's where our total experience can help. Because only through a total look at your production situation can you be sure you're getting the greatest yield per dollar invested.

For the most profit.

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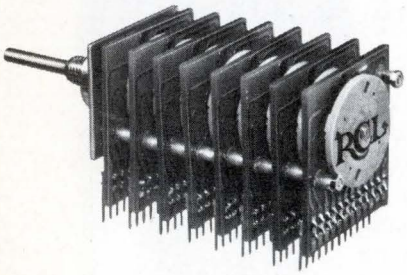


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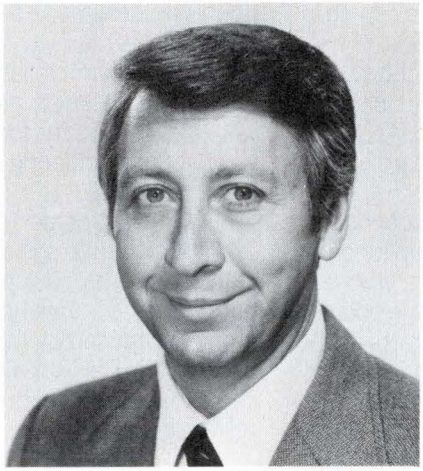
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People

Fairchild Industries' Friedman eyes earth-station hardware

The "communications pot at the end of the rainbow" is what Fairchild Industries' Space and Electronics Co., Germantown, Md., is aiming at, says its new vice president for advanced systems, Robert F. Friedman. Recently named to direct Fairchild's venture into commercial communications hardware, the 44-year-old electrical engineer is out to sell ground stations to companies needing to communicate via satellite.

The market possibilities are already in the tens of millions of dollars, he points out. Included in his estimates are such projected buys as the 150 receive-only terminals for the Public Broadcasting System—worth at least $15 million, he says. And Television News Inc., a relatively young news-gathering service, is looking over bids for 25 receive-only terminals to be installed at clients' broadcasting studios. If the initial net proves itself, Television News might spend as much as $25 million for ground stations, according to Friedman. And further downstream is a market for terminals on offshore oil rigs, worth another $25 million, he says.



Ground man. Friedman adds up lots of dollars for ground satellite terminals.

Fairchild is also "thinking about" installing local distribution networks, a charter that the dapper and athletically trim Friedman would certainly like to get. For two years he was operations vice president of Fairchild's specialized common-carrier subsidiary, American Satellite Corp., so he's aware of the problems involved in providing access to satellite channels.

"The technology is getting to the point that economic local distribution is 'do-able,'" Friedman says, with money to be saved by avoiding the land-lines network of the Bell System. Friedman's group is already evaluating a prototype local-distribution terminal—a time-division multiple-access system with a 6-foot array antenna. Able to transmit data, voice, and television for nationwide communications via satellite, the terminal "would be adequate for a medium-sized city," Friedman says.

He views his new job as the fruition of 15 years in the communications business. "My experience in international, military, and domestic carrier communications comes to a focus in this new thrust," he says.

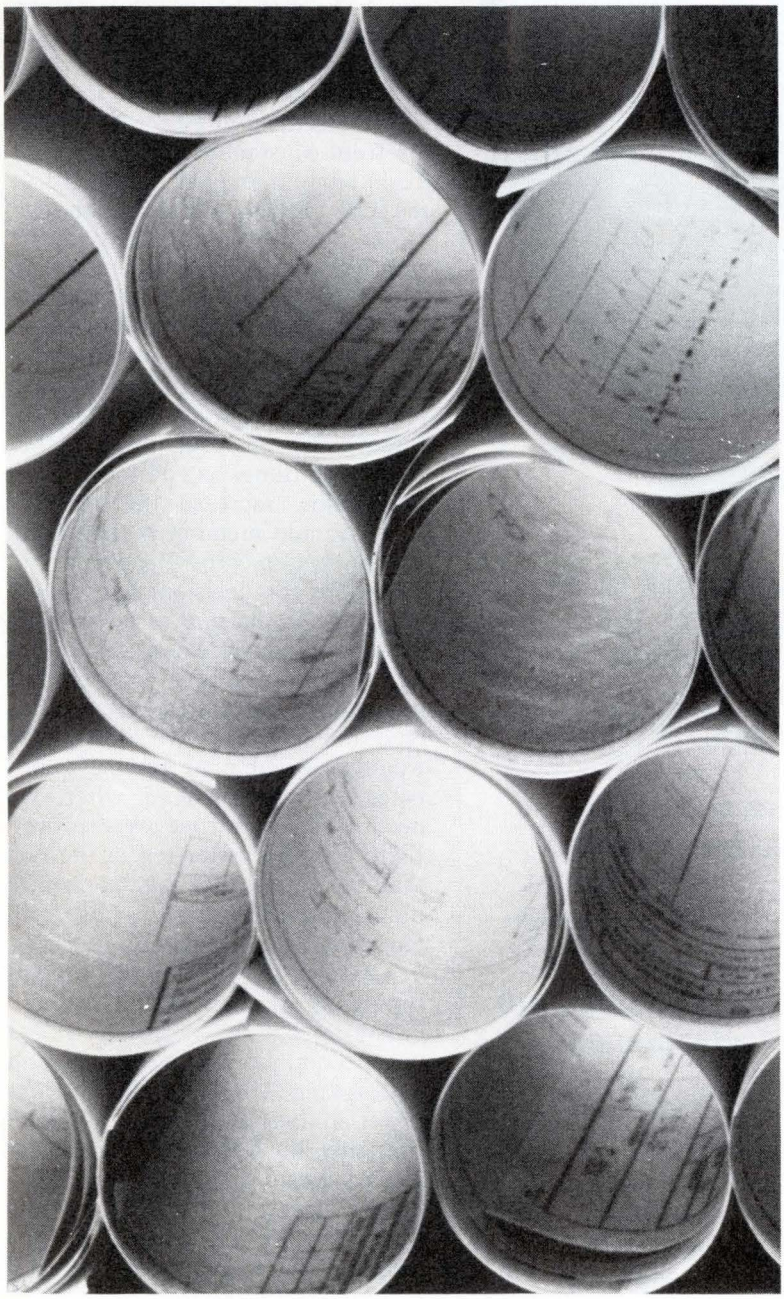
DEC's Teicher finds he likes microcomputer design

Steven Teicher was eager to work on big computers, like the room-sized Decsystem 10, when he joined Digital Equipment Corp. in 1969. But somewhere along the line he about-faced, obviously with good reason, because today at 31 he is product manager for the very smallest end of DEC's PDP-11 computer

Micro man. The orders for DEC's LSI-11 have been "phenomenal," says Teicher.



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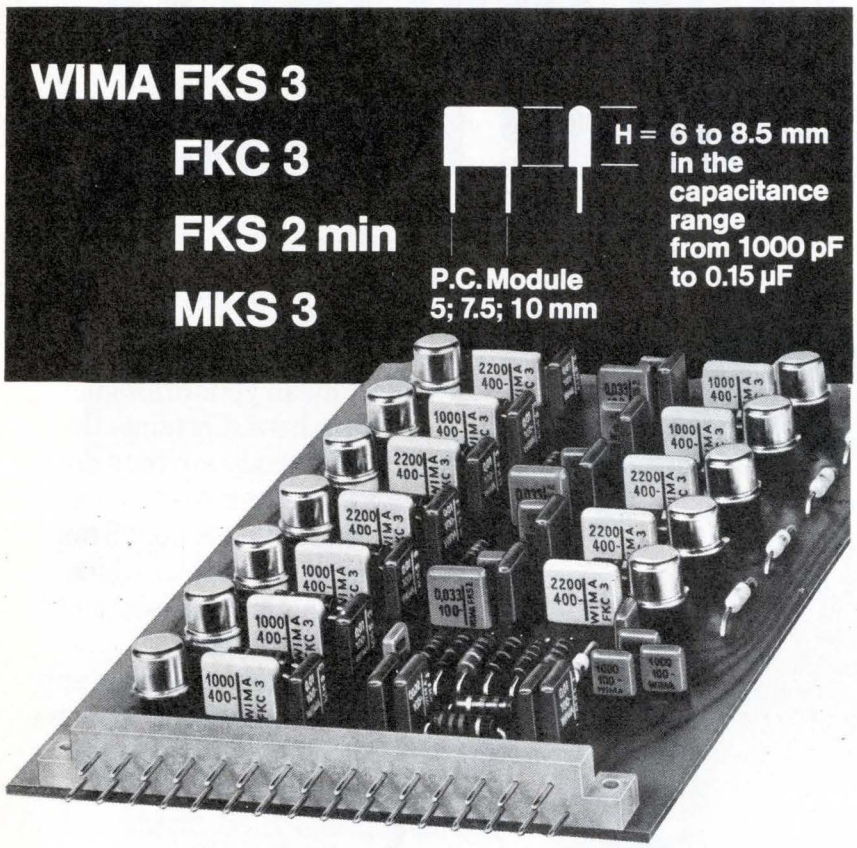
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People

line. His group recently introduced the LSI-11 microcomputer [*Electronics*, Feb. 20, p. 114], a 16-bit processor with a 4,096-bit memory on a single circuit board. It sells for only $634 in quantities of 100, and, so far, it's had "the most exciting response of any product we've introduced," says Teicher. "The orders have been phenomenal."

Teicher, credits the booming sales to the LSI-11's applications in areas like remote data handling and industrial processing, where computers have not been used before. Minicomputers are too big, too powerful, or too expensive, and microprocessors lack power, he says.

The electrical engineering graduate from Massachusetts Institute of Technology managed the design of the LSI-11 from its inception two years ago. And he's likely to be working on it for some time to come. Better ways of packaging the microcomputer can still be developed, he says, as well as lower the system cost still further. He's also taking a look at how the unit is partitioned and "investigating whether to do such things as add more interface chips, increase the memory size, and add memory management and protection chips," he says.

Perhaps the decision that pleases him most is the one to go with n-channel semiconductors for the design. Complementary MOS circuits on sapphire substrates were considered and rejected. "We thought we wouldn't be able to get the quantities we would need when we needed them, and we were proved right," he says, referring to the fact that such potential C-MOS-on-sapphire suppliers as Inselek Corp. and Rockwell International Corp. [*Electronics*, Dec. 26, 1974, p. 23] stopped supplying commercial units.

The n-channel devices yield a "good combination of density and performance" and are likely to improve in the future, says Teicher. Presently, his sole source for the devices is Western Digital Corp. [*Electronics*, Oct. 31, 1974, p. 25]. But in a month or two, he expects to start testing n-channel chips from several potential second sources.

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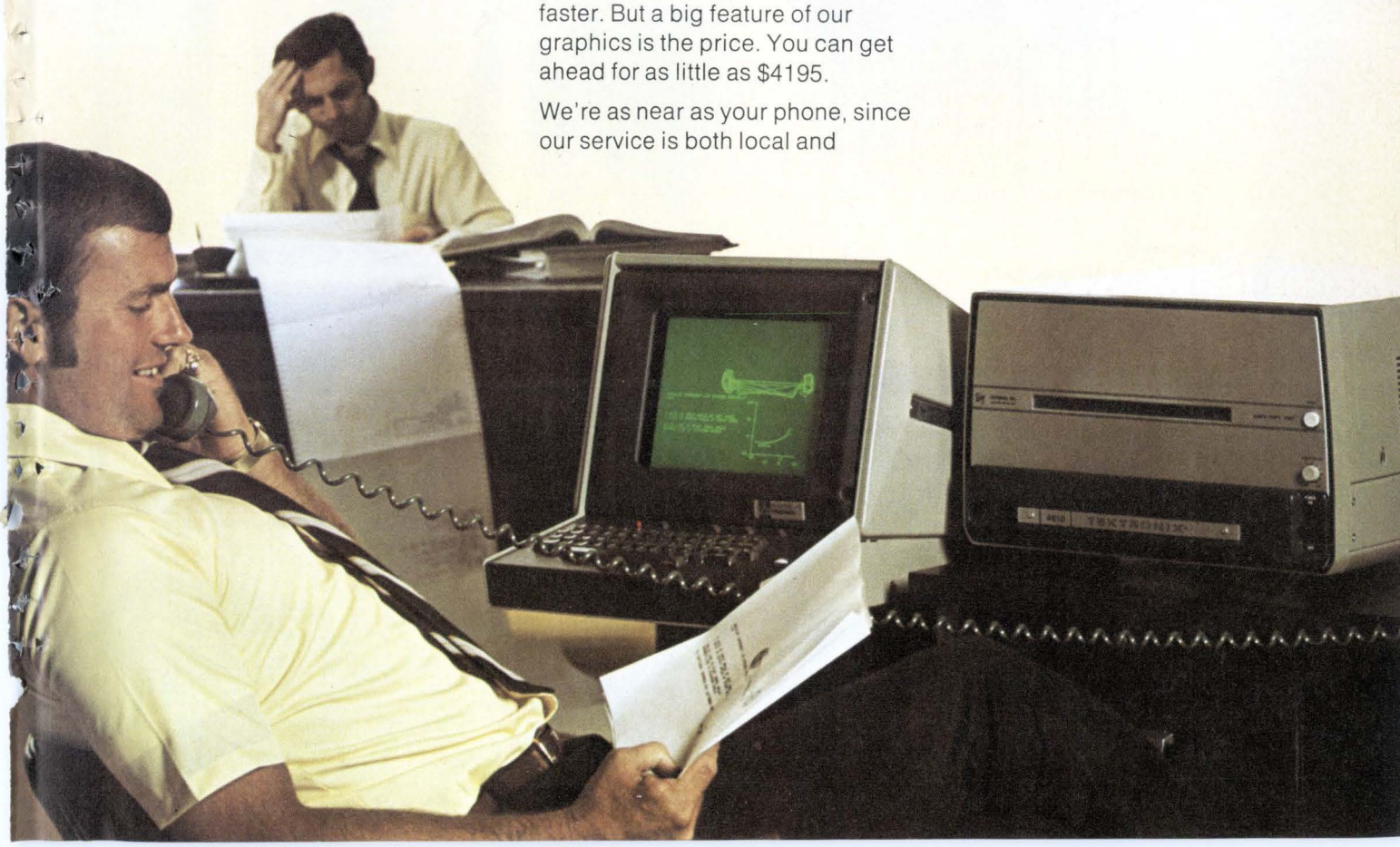
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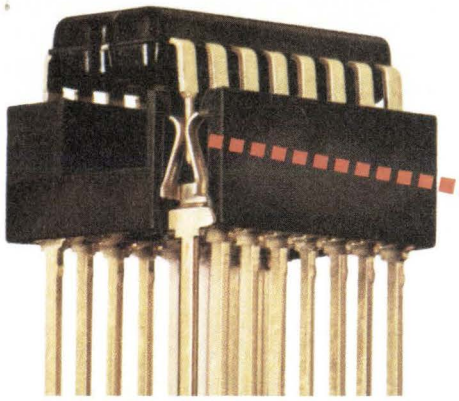
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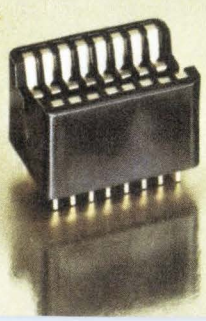


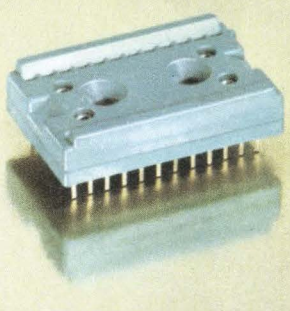
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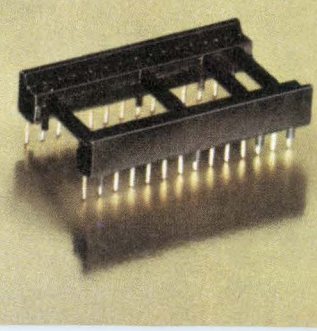
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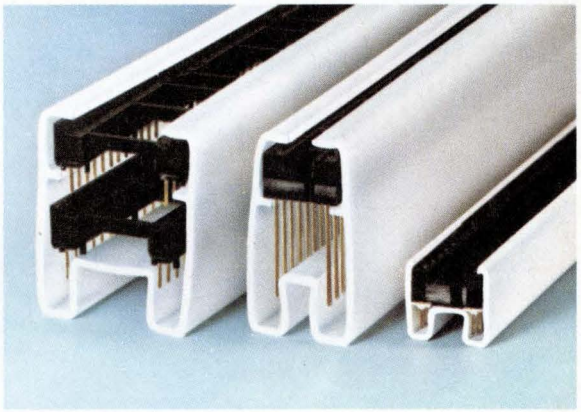


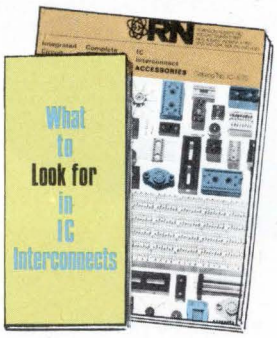
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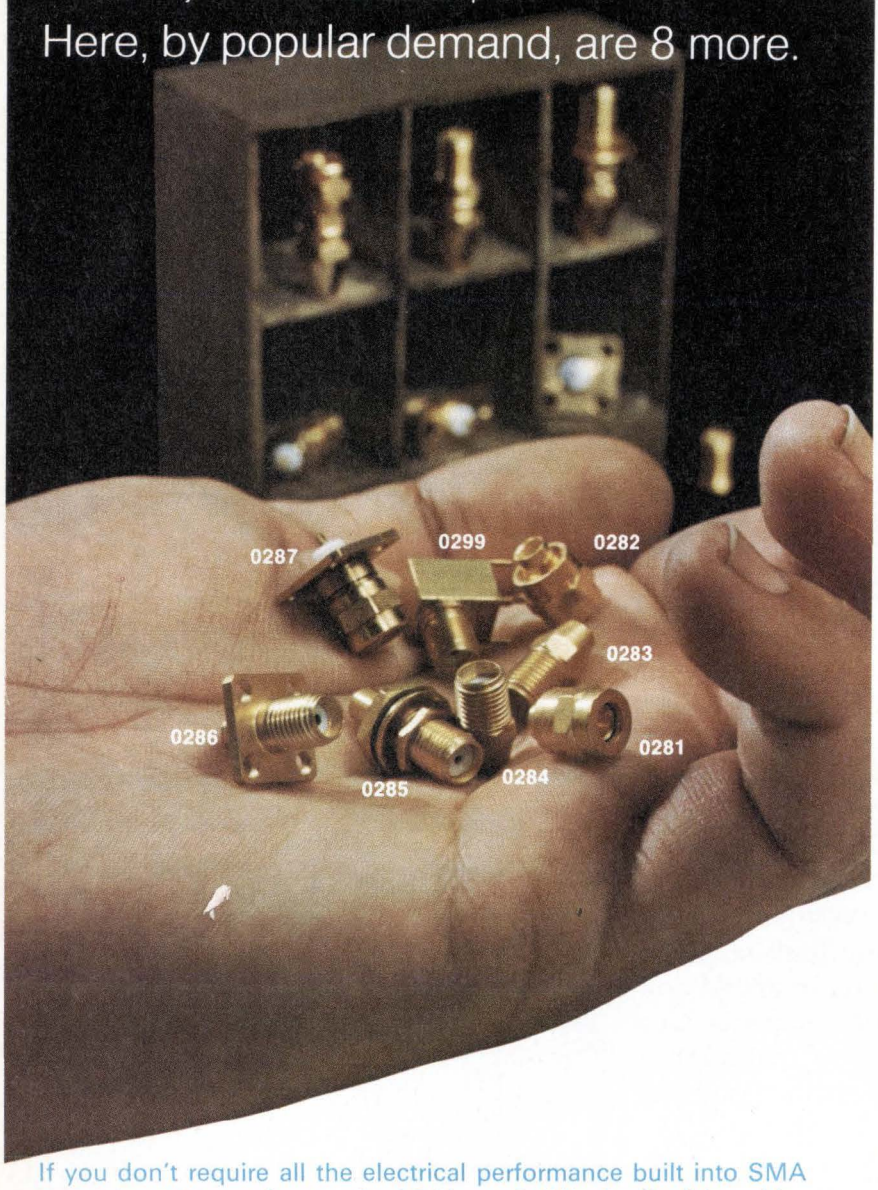


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Reliability Software International Symposium, IEEE, International Hotel, Los Angeles, April 22–24.

Society for Information Display International Symposium, SID, Shoreham Americana Hotel, Washington, D.C., April 22–24.

International Optical Computing Symposium, IEEE, Mayflower Hotel, Washington, D.C., April 23–25.

National Relay Conference, NARM and Oklahoma State University, Stillwater, Okla., April 30–May 1.

American Ceramics Society Electronics division Meeting, Sheraton Park and Shoreham Americana Hotels, Washington, D.C., May 3–8.

Photovoltaic Specialists Conference, IEEE, Hotel Valley Hotel, Scottsdale, Ariz., May 6–8.

Carnahan Conference on Crime Countermeasures, U. of Kentucky and IEEE, Lexington, Ky., May 7–9.

International Microwave Symposium, IEEE, Rickey's Hyatt House, Palo Alto, Calif., May 12–14.

Electronic Components Conference, IEEE, EIA, Statler Hilton Hotel, Washington, D.C., May 12–14.

Electrical and Electronic Measurement and Test Instrument Conference, IEEE, Skyline Hotel, Ottawa, Canada, May 13–15.

Audio Engineering Society 51st Convention, AES, Los Angeles Hilton, May 13–16.

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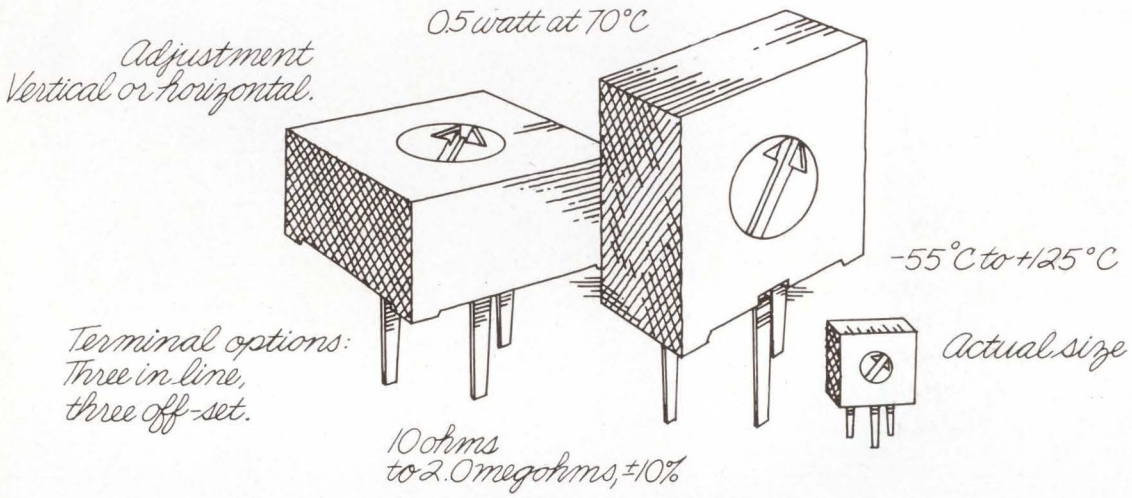
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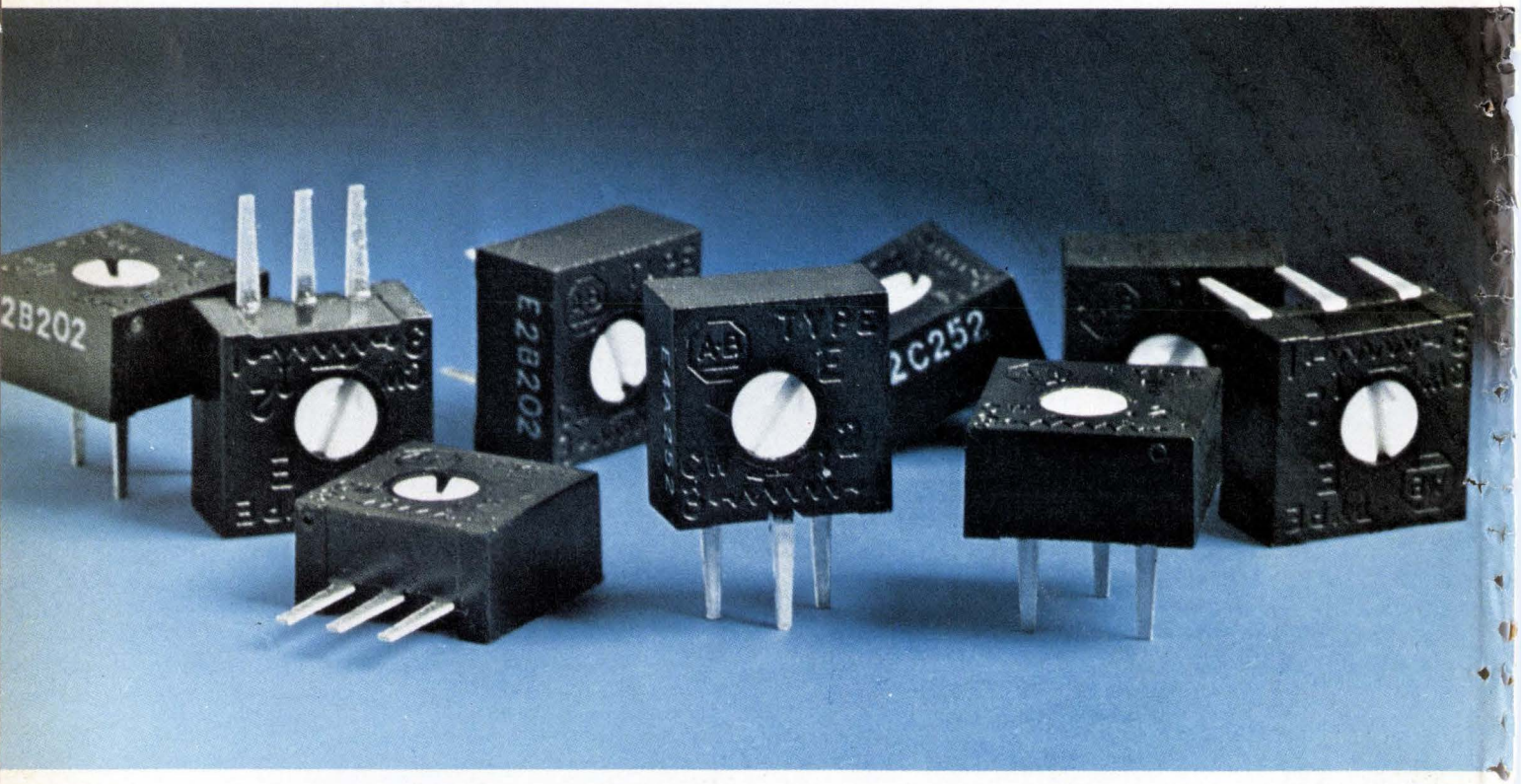
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Electronics newsletter

National planning I²L watch module

National Semiconductor is developing an integrated-injection-logic watch module. Floyd Kvamme, vice president and general manager of the Semiconductor division, says the module—intended for light-emitting-diode displays—will be ready this year. National, which up to now has been a supplier only of C-MOS watch chips, thus **becomes the second semiconductor watch module manufacturer**—joining Texas Instruments—to exploit I²L's low-power, high-density capabilities for watch applications. The company also has a development program for I²L microprocessors intended to yield products by 1976.

Benrus seeks to sell watches to Swiss firm

Benrus Corp. is negotiating the sale of a digital watch of its own design to a leading Swiss watchmaker. Benrus normally buys integrated-injection-logic LED modules from Texas Instruments and C-MOS LED modules from Hughes Aircraft Co., **but plans to sell the Swiss a Benrus-assembled and cased C-MOS LED model** featuring five functions—hour, minute, second, month and day/date.

Benrus, meanwhile, has delivered its first women's digital watch, based on Hughes' two-function module, **and is breadboarding a watch module with alphanumerics,** displaying an abbreviated day of the week—MO for Monday, TU for Tuesday, etc. Benrus expects to incorporate this feature in a watch by year's end.

Motorola mounts M6800 drive . . .

Officials at Motorola's Semiconductor Products division are counting on second-quarter shipments of the M6800 microprocessor family to establish the division as a highly visible competitor in that business. Colin Crook, MOS marketing manager and manager of the M6800 program, says **shipments this quarter will be in the tens of thousands of units** for the 8-bit family, and that the customer list already includes Hewlett-Packard, Tektronix, TRW Systems Group, Chrysler's Huntsville, Ala., auto electronics operation, and Motorola's own Communications division.

Distributors are being stocked with the M6800 family, and the division is also offering an introductory kit that includes the family's six initial parts, plus applications and programing manuals, for $300.

. . . as it unveils 16-pin 4-k RAM

Motorola is also more sharply polarizing the 4,096-bit RAM business by taking the wraps off its MM6604, a 16-pin device that will be targeted at a 200-nanosecond access. Intel's 16-pin unit will have a similar speed spec. **The 6604 went from design to production in just three months with Motorola's own n-channel process and its own design.** The move comes just after it became known that National Semiconductor Corp. had secured Signetics Corp. and Advanced Memory Systems as alternate sources for its 18-pin 4-k RAM. Motorola will have samples of the 6604 fully characterized this month.

Meanwhile, Texas Instruments has Advanced Micro Devices as a second source for its 18-pin 4-k RAM, with Fairchild joining Motorola and Intel as champions of the 16-pin approach originated by Mostek Corp. with its MK4096.

Electronics newsletter

Japanese seeking jet fighter replacements

Now that it appears likely that General Dynamics' F-16 has nosed out the F-17 and the Mirage entries as NATO's choice to replace its member nations' aging F-104 fighter planes, another competition is getting under way. A special mission from the Japanese defense agency, **which wants to replace the 180 F-104s in its air force,** will visit the manufacturers of seven potential choices for two months beginning at the end of May. The contenders are the F-14, F-15, F-16, FY-17, French Mirage F-1, trination European MRCA, and Swedish Viggen.

Ground-warning system specs due from FAA

Specifications for jet aircraft ground-proximity warning systems will be published by the end of the month, says the Federal Aviation Administration. **But one proposed function—to warn pilots if the airplane's angle of airport approach is too low—won't be included,** says the FAA. Other functions warn pilots if takeoff altitude is adequate, if extended landing gear can't be retracted in time to avoid trees or radio towers, or if an airplane's altitude is too low while cruising or changing course.

System originator Sundstrand Data Controls Inc. claims its landing-descent mode works, but Pan American World Airways disconnected that mode on its Sundstrand-equipped planes, saying there had been numerous false alarms.

Control Data to reveal mass-storage unit

Control Data Corp. of Minneapolis, Minn., will announce at next month's National Computer Conference **the development of a mass storage system.** Control Data's announcement follows one by IBM [*Electronics*, Oct. 31, 1974, p. 28] of the 3850 system, which stores almost 4 trillion bits. The Control Data system's capacity will be in the same range.

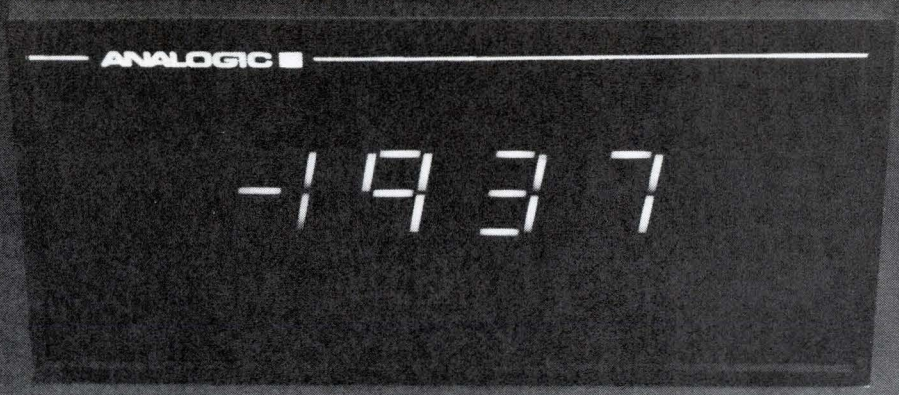
Analogic wins proprietary data action

A Massachusetts judge has accepted the verdict of a previous 63-page report and ordered Data Translation Inc. of Framingham, Mass., to pay almost $13,000 for damages through Nov. 1, 1974 to Analogic Corp. Analogic, a Wakefield, Mass., maker of signal converters, digital panel instruments, and digitizing systems, claims Data Translation officers, some of them former Analogic employees, **used proprietary Analogic secrets to make high-speed data-acquisition systems.**

Radio-telephone tester is based on microprocessor

Schlumberger, the big French instruments maker, is about to introduce a microprocessor-based automatic test and measuring system for radiotelephone communication equipment. **Thanks to the microprocessor, the system, called model 4930 and selling for about $42,550, can handle more than 30 measuring programs.** Among the test routines and transmitter/receiver parameter measurements are sensitivity and bandwidth, center frequency, squelch level, audio-frequency response, image rejection, radiated power, modulation sensitivity, interchannel modulation and signal-noise ratio. The model 4930 test system, to be unveiled in Paris late this month or early next, boasts measuring accuracies that are said to be better than those specified by European communication administrations. The 4930 will cost around $42,550, according to a Schlumberger official in Munich.

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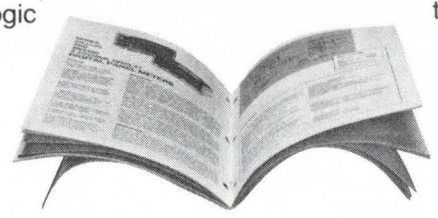
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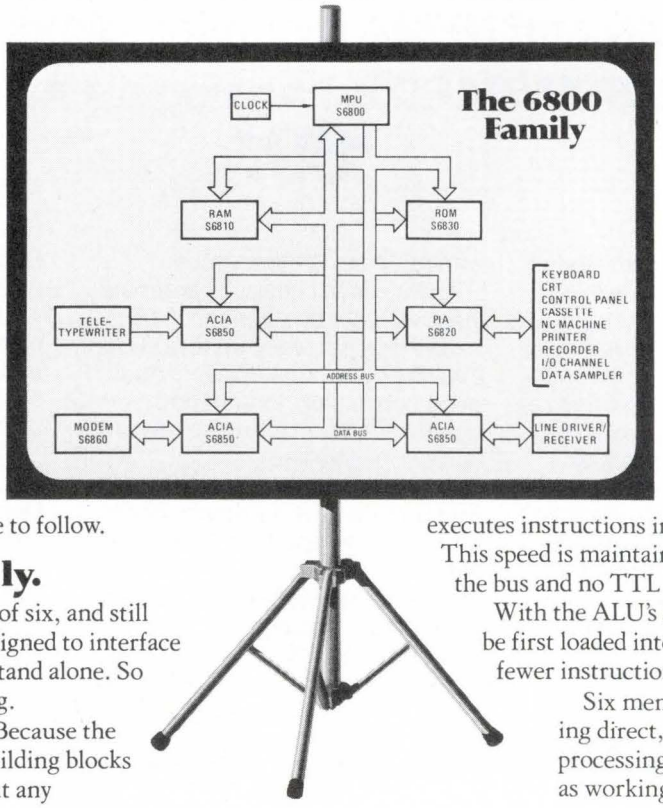
Micropr

It's a whole new era for microprocessors. And a whole lot of people are sorry they started without us!

The S6800 Microprocessor family is getting rave reviews from designers, magazines and engineers—even those already committed to the 8080.

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To put it simply, it's already the industry standard that all other microprocessors will have to follow.



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That can save you a bundle. Because the 6800 gives you standard LSI building blocks to put together a system without any restrictions on peripherals.

It's less costly because it requires fewer parts. It runs on just one +5V power supply instead of three. It has a more efficient instruction set, which reduces the number of locations needed in memory because of six memory addressing modes. And it needs no TTL to bring it together.

Better design gets better results.

Although the 5 volt clock operates at only 1 MHz, it still executes instructions in a minimum of 2 microseconds. This speed is maintained with up to ten devices on the bus and no TTL buffering.

With the ALU's ability to hold data, it need not be first loaded into an accumulator. The result is fewer instructions and faster program execution.

Six memory addressing modes (including direct, extended and indexed) make list processing, and the use of external memory as working registers, very fast and efficient.

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The S6830 static ROM, with its 1024 x 8 organization, is the densest, fastest (575 ns access max.) read/only memory with a single power supply.

The S6850 Asynchronous Communications Interface Adapter provides data formatting and control to interface serial asynchronous communications to bus organized systems like our MPU.

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The S6800 MPU gives you these features:

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- Two accumulators
- Decimal and binary arithmetic
- 65K bytes memory addressing
- Maskable and non-maskable interrupts
- External variable length stack
- 72 basic instructions
- Six addressing modes
- Variable length instructions
- TTL compatibility
- Three state outputs
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Air Force wants standard microcomputers for its aircraft

Networks of microcomputers may take over computing functions; designs to be independent of process

Because microprocessors are gradually replacing other kinds of logic in military hardware, the U. S. Air Force is exploring a scheme to use them as the main computing resource on aircraft. More concretely, it is looking at a standard network of distributed microcomputers for handling conventional avionics functions, all interconnected by a serial 1-megabit dedicated data bus.

At the end of this month, Texas Instruments will present the Air Force Avionics Laboratory with a detailed report on the necessary software and hardware design. The Dallas firm has also written a three-level software simulator for testing the two-level bus scheme and the proposed instruction repertoire and for simulating the microcomputers on a register level.

The TI document projects considerable cost savings with the microcomputers, assuming a 1980 implementation date. Commercial-grade microcomputers in 5,000-unit quantities are tagged at $350 each, and military-grade systems at $1,745. That's about a tenth of what the Air Force now pays for general-purpose airborne computers, points out Michael J. Moore, project engineer in the laboratory's System Avionics division at Wright-Patterson AFB, near Dayton, Ohio. The network is designed to handle a mix of semiconductor technologies: complementary and n-channel metal-oxide semiconductors, integrated injection logic or anything else that can be qualified to military standards.

Honeywell original. The idea for a distributed processor/memory system, as it's called, was originally advanced by Honeywell Inc.'s Systems and Research division, St. Paul, Minn., under an earlier Avionics Lab contract. After analyzing eight avionics functions, including strapdown and platform navigation, flight control, Loran, the microwave landing system, and electronic intelligence, Honeywell concluded that the microcomputer needs a 16-bit word length, between 4 and 8 kilobytes of memory, and a throughput of 250,000 instructions per second. The firm designed a two-level bussing scheme to obtain 1-megabit data rates between microcomputers and, where needed, to link two or more microcomputers.

The standard processing element,

Standard microprocessors due in July

Although a standard network of microprocessors may be the answer for tomorrow's equipment, the U.S. Air Force also intends to do something about the proliferation of microprocessor types in today's gear. Fearful of being stuck with many unique systems requiring extensive software and hardware support, the Air Force Aeronautical Systems division wants a standard device that could be applied across the board.

That device is referred to as a UDAM, for universal digital avionics module, and ASD will see the first chips of the four-chip baseline set in July. Chip architecture is independent of chip process, so that devices may eventually be either complementary metal-oxide semiconductor or C-MOS on sapphire or integrated-injection logic. But the first two custom chips, a control unit and an arithmetic unit, will be n-channel MOS with 0.2-mil-wide channels, built by Nitron Corp., the Cupertino, Calif., wafer-fabrication facility of Actron Industries Inc., a subsidiary of McDonnell-Douglas Corp. Control read-only memory and data random-access memory for the 16-bit device will be selected from commercial units, says Michael F. Yackowsky, UDAM program development manager at Wright-Patterson AFB, Ohio.

The Air Force is unwilling to project likely production quantities for what it hopes will be a triservice development, but the standardization program is seen as a way to get volume leverage with semiconductor manufacturers. Yackowsky estimates that such a chip set could be applied to about 60% of the avionics functions on an aircraft, in both new and retrofit systems. For some aircraft types, this could add up to 150 chip sets per plane.

The chip set will operate at a 2-to-2.5-megahertz clock rate. Adding and subtracting will take 0.8 microsecond, and the worst-case multiply execution time will be 6.8 microseconds, Yackowsky says. Though the set has a 16-bit word, the arithmetic unit can be expanded in 8-bit jumps from 8 to 80 bits per word. The current $360,000 contract also requires Actron to implement the microprocessor sets for systems tests in units such as multiplex controllers and "smart" terminals. The program's final phase, expected a year from now, is qualification to the MIL-M-38510 standard.

the microcomputer, will have a microprocessor, memory, input/output port, and two bus interface units—a total of about 40 chips of six or seven different types, Moore explains. All will be tied together with a single-channel, parallel-data-path, synchronous bus, similar in concept to the PDP-11 Unibus of Digital Equipment Corp.

The single-channel I/O operates in two modes: either as a standard program-control I/O, or as a direct memory-access channel. The two bus-interface units are identical and probably could be implemented with a microprocessor controlled by a read-only memory, Moore says. Sixteen 4-k or 8-k random-access memories are also required. The microcomputer chip set, as defined now, includes an arithmetic logic unit, a ROM for program control, eight general-purpose registers, a full complement of logic instructions, about 40 basic instructions with six address modes, and 10 primary levels of interrupt, he says.

As a network, each microcomputer is attached to a redundant "global" bus. Avionics subsystems requiring more than one can also be linked by local busses. One microcomputer serves as the global executive. It contains scheduling information for the subfunctions "and has to be smart enough to receive pilot control-console command information and to aid in fault recovery—reconfiguring the system in case of partial failure." Moore explains.

TI's $223,000 contract for system design and software support ends this month. The Avionics Lab's next step is to build a network "test stand" and to write a request for proposals for a network breadboard. Expected later this year, that two-year contract will yield a four-microcomputer network. □

Military electronics

Military computer design yields machines with three word lengths

Developing a possible successor to the U.S. Army's standard 32-bit computer, Litton Data Systems Inc. has also taken a crack at a pair of smaller computers along the way. The result is a modular computer, the L-30, made up of printed-circuit cards that can create a 16-bit minicomputer and an 8-bit controller.

Litton now makes the Army's AN/GYK-12 computer, which it designed in 1966 with transistor-transistor-logic gates and flip-flops. It is used in the Army's Tacfire artillery fire-control system, the TSQ-73 missile-control system, and Tri-Tac communications switches. The L-30 emulates the operation of the AN/GYK-12, including speed, permitting the use of the huge existing software base and peripherals. However, it will be half the size and cost of the AN/GYK-12, fitting in a military case, 33 by 26 by 9 inches.

Significantly, the 16-bit minicomputer made from the L-30 cards emulates the commercially available Modcomp II minicomputer from Modular Computer Systems, Fort Lauderdale, Fla. This design approach permits prospective military users of the Litton computer to develop their systems around the Modcomp computer and its already available software, with substantial savings over having to use full military hardware. Litton sees one possible use for the 16-bit machine in a smaller, battery-level version of the Tacfire system for smaller countries that do not use the battalion-level U.S. Army system.

Modcomp emulator. Litton chose to emulate the Modcomp computer, says Jerry Weissman, director of advanced systems and products, because its architecture is similar to the one Litton was already working on. "We could emulate any minicomputer, but the similar structure makes this especially easy and efficient. We microcoded most of the Modcomp instructions in only about a week." He adds that Modcomp has done a lot of communications work, which is a requirement in Litton's applications. The work with Modcomp is informal and involves no licensing since Litton isn't copying the hardware, he points out.

The Litton Industries Inc. division, based in Van Nuys, Calif., was able to achieve this versatility through the use of a modular, bit-slice architecture such as that used in recently announced bipolar microprocessors, plus microprograming contained in read-only memories. The circuitry used, however, is fast Schottky-TTL medium-scale integrated circuits rather than microprocessor chip sets.

Leon Bloom, manager of advanced computer development, says that none of the available microprocessors was fast enough when development began 1½ years ago. Some recently announced microprocessors might be speedy enough and might be used in some future production computers to slightly reduce card count, he adds. At present, either high-speed or low-power Schottky TTL is used, depending on requirements. Basic add time is 2.4 microseconds for the 32-bit computer.

Eight-bit slice. The computer family uses 8-bit-slice data cards, with four required for the 32-bit AN/GYK-12 emulator. It also uses a 4.3-megabit mass core memory developed for the present computer as an alternative to tape or disk storage. "We could use a 600-nanosecond core memory with the high-speed Schottky computer, but we're not pushing that now," says Weissman.

The 8-bit version, really a peripheral controller rather than a full computer, uses four cards in all, an 8-bit-data-slice card, a central processor unit interface card, a microcontrol card, and a peripheral interface card with a read-only-memory microstore. The 16-bit minicomputer version uses 13 cards, including six in a dual 8,192-by-16-bit, 900-ns core memory.

Litton, which developed the fam-

ily with its own funds, has built a 16-bit minicomputer breadboard using the low-power circuits, and is now completing a 32-bit version using high-speed chips. The division expects to have a military-qualified minicomputer by August and a 32-bit AN/GYK-12 emulator ready to plug into a Tacfire system by September. □

Industrial electronics

Laser camera helps textile printing

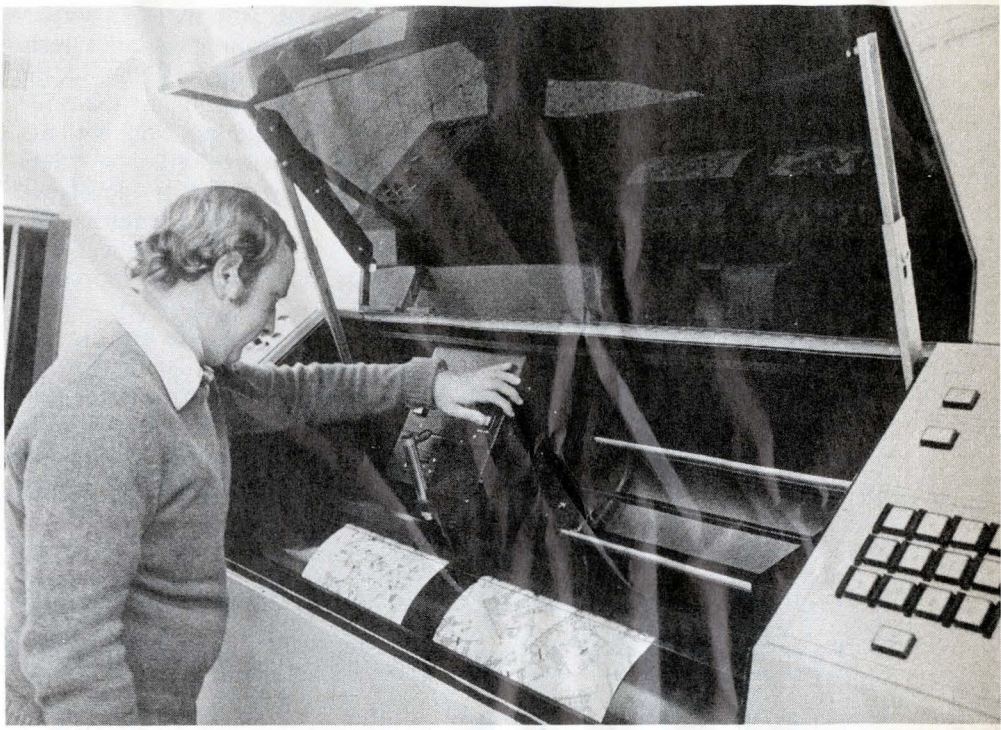
In the competitive and fashion-conscious textile industry, the ability to turn a design around quickly from a sketch to finished goods is crucial. Realizing this, a small Israeli company, Sci-Tex Corp., four years ago took an optical-scanning technique originally developed for military reconnaissance and applied it successfully to the problem of designing patterns in double-knit fabrics.

Now, Sci-Tex has added a laser camera—and $120,000 in price—to its original unit to produce a design aid for the decorative printing trade, easing the creation of fancy wallpapers and textiles. But even with its hefty $400,000 price tag, Sci-Tex's president Efraim Arazi expects the system to do well.

"Printing is an old-fashioned industry in which most of the existing machinery was built 40 years ago," he says. "Simply put, our new machine will save time. In one hour it will convert a sketch into color separations, from which printing engravings can be made. To do that operation now [by hand] averages 200 man hours."

Computer-aided design. The input to both the machine for double-knit patterns, called the Response system, and the machine for the printing trades is a fashion designer's sketch. Outlines and colors are converted to digital codes by an optical scanner. The output is a code that can be used to control the knitting machine or the laser camera.

The heart of the system, though, is an interactive terminal with a color cathode-ray-tube display. With it, an operator can vary color combinations and make changes in the design by using an electronic stylus and tablet. In less than 15 minutes, a sketch for a fabric can be converted to a tape that can be used to produce a fabric sample—a process that previously took weeks.



Printer. The optical scanner used in Sci-Tex Corp.'s design aid for the printing industry takes artist's pattern with as many as 12 different colors and converts it digital code. Design can then be manipulated via color crt.

For the new printing version, the same quartz-halogen-lamp optical scanner as in the double-knit machine is used. Light reflected off the pattern is broken into red, green, and blue beams by filters and picked up by three separate photomultipliers. The resulting three-dimensional color vector is compared to vectors representing the maximum of 12 colors (a printing machine may print up to 12 colors) stored in the memory of the system's Hewlett-Packard 2108A computer.

When the scan is completed, the computer contains a matrix of codes that indicate the color in each increment of the design. Typically, there are 400 increments per inch. Simultaneously, the sketch is displayed on the color screen, and the operator may modify it, drawing from a separate library of 999 colors.

Once the operator decides the pattern is ready, the information is used to control the laser camera. The camera uses a Spectra Physics Corp. 15-milliwatt argon laser and an acousto-optic modulator to reproduce each color pattern on conventional black-and-white film. Triggered 500,000 times per second, the laser produces lines that average 400 dots per inch. Then a step-and-repeat camera exposes up to 12 color separations that may measure up to 72 by 42 inches.

"The camera would not have been feasible," notes Arazi, "if it had not been for the recent development of a long-life—2,000 hours versus 300 hours—argon laser."

There were other design problems, however. "We had to pay more attention to human engineering and reliability than I ever did as an aerospace engineer," Arazi says. "We had to do three times more software than is usually necessary because we wanted to ensure that

the operator learning would be minimal. And we had to make the equipment very forgiving so that an operator mistake doesn't blow the system." □

Consumer electronics

Quaking sensation comes to the movies

The current wave of disaster movies is proving to be anything but that at the box office. And the phenomenal success of at least one movie, "Earthquake," results to an important extent from electronics technology. Since it opened Nov. 15, the movie has grossed more than $31 million. Earthquake's clout with audiences is attributable to "Sensurround," a specially developed sound system that engulfs the movie-goer with low-frequency vibrations that seemingly reproduce the effects of an earthquake.

"The waveform sent out through the system closely simulates the waveform recorded by seismologists at the California Institute of Technology [in Pasadena] during the February 1971 earthquake around Sylmar, Calif.," says W. O. Watson, a sound-system consultant. Watson, together with producer Richard J. Stumpf of Universal City Studios Inc., Universal City, Calif., developed Sensurround. "However, since the vibrating sensation is airborne and not carried through the theater structure, there is no physical danger to the audience."

Sound track. The sound sent out into the theater is triggered by signals on the film—discrete tones recorded on the optical sound track. These tones turn on a control unit, and a pseudorandom-noise generator recreates the rumble of an

Paris Components Show finds pessimism but European semiconductor makers eye U.S. market

Usually the Salon International des Composants Electroniques in Paris—the Paris Components Show—is a hectic place. But this year the pace was slower, people were easier to find, and discussions between vendor and customer were less intense.

This, explains Olivier Garreta, general manager of the Sescosem division of Thomson-CSF, resulted not from a drop in attendance but from a lack of orders. "I'm much more pessimistic now than I was at the beginning of the year," says Garreta, head of the largest French-owned semiconductor firm.

Like many others at the show, he sees no upturn soon. However, Francois Dufaux of Texas Instruments France, senses some improvement but emphasizes that companies really haven't reached the ordering point. He expects a technical upturn in the second half to rebuild depleted inventories.

Despite the business climate, European companies aren't neglecting new product development, though often they prefer to look for niches in a market rather than compete head on with American firms. Thus Garreta reports that by mid-year his group will have decided on its entry into the microprocessor market. "We have the building blocks, and we are determining what to build."

Sescosem is further along in another effort—a 4,096-bit random-access memory. An n-channel product will be sampled in mid-1976, in time to grab a share of the European market, the company hopes.

Another firm taking this careful approach to high-technology new-product development where American firms excel is RTC-La Radiotechnique Compelec, a components-producing affiliate of the Philips group. "We prefer to be a little bit late," says Daniel Ameline, head of semiconductor marketing. RTC has developed a special-purpose microprocessor for one customer and plans to offer it to the general market later.

One area getting close attention is watch circuits. Obviously, the stakes are high, Garreta says, citing the annual production of 20 million mechanical watches in France, 40 million in Russia, and 80 million in Switzerland. In fact, the French government is even considering supplying an incentive in the form of R&D money.

One potential market that has somewhat disappointed semiconductor firms is automobile electronics. "We still believe in it," Garreta says, "but it will take much longer to develop than we first thought."

When it does develop, around 1980 according to Garreta, he believes European firms will have a good shot at it. "First, we are even with, if not ahead of the Americans in auto technology. Second, the electronics supplier will have to work closely with the car companies. Thus we'll have the advantage in our home market."

In another area, Sescosem also reflects the attitude of other European semiconductor firms whose interest in the U.S. market is increasing. Philips, for example, recently made a move to acquire Signetics Corp., the Sunnyvale, Calif., semiconductor manufacturer. But Siemens, which already owns the Arizona-based zener diode and capacitor maker Dickson Electronics Corp., says it has no plans either to expand this facility, buy another or otherwise increase its activity in the American semiconductor market.

Sescosem's U.S. sales still does not approach the 1% to 2% of the U.S. market it would like to achieve—a magic figure mentioned by other firms—and to achieve this figure will eventually take a manufacturing plant in the U.S. "In the long run, we can't stay out," Garreta says.

He's unwilling to indicate an active interest in acquiring a U.S. firm, but he asserts, "It's too complicated to build a plant in the U.S."

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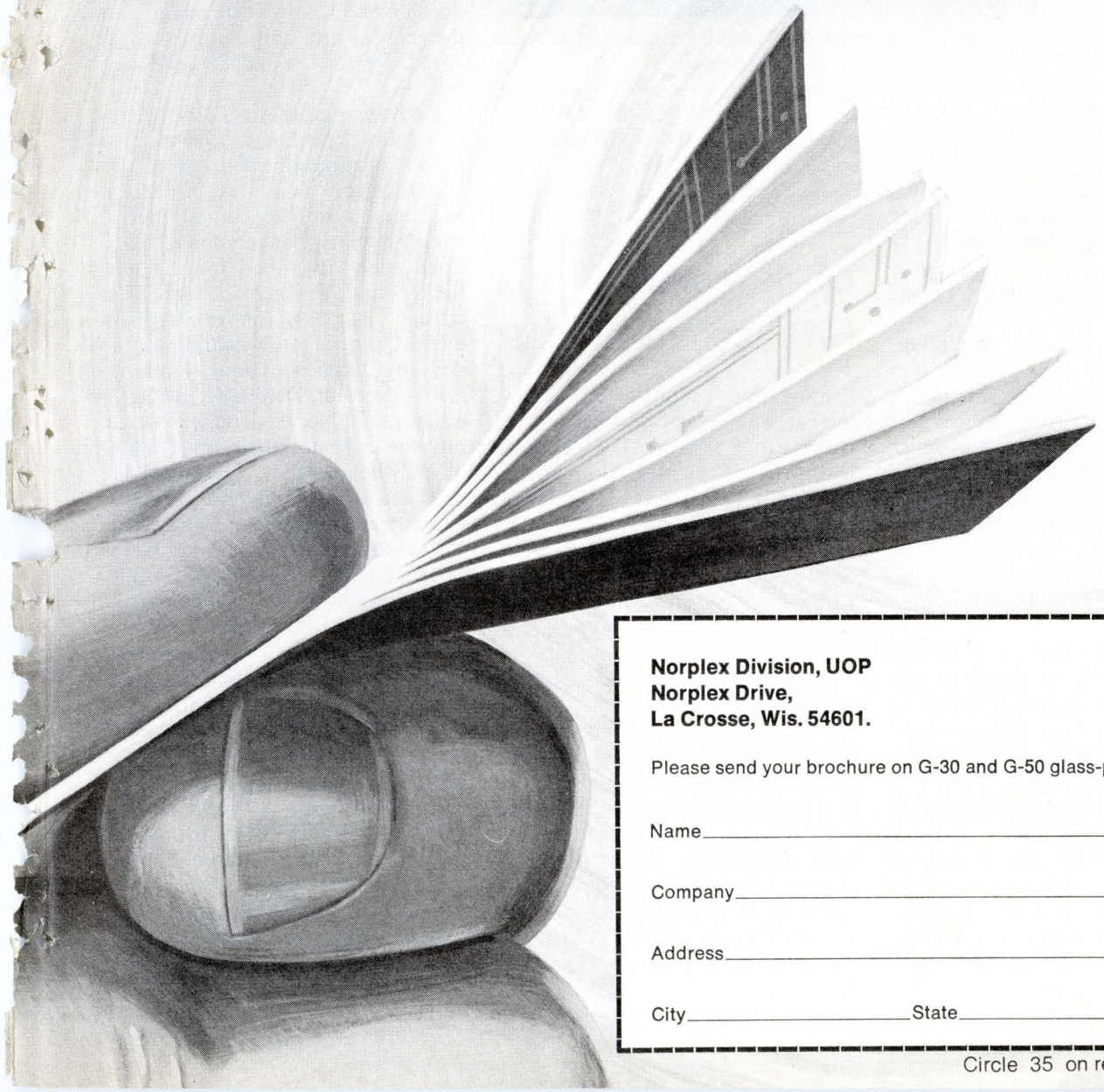
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earthquake. The signals are fed to audio power amplifiers that drive proprietary transducers of an especially sturdy design, and these are placed in horns around the theater. The audience is bombarded by a high-intensity low-frequency rumble that ranges between 15 and 100 cycles. "Below 20 cycles you don't hear, but you feel," comments Watson.

While the earthquake sounds are being created, the level of the sound in the theater is increased as much as 6 to 10 decibels above the normal level of dialog. Moreover, the material on the movie's sound track is also fed into the Sensurround system to give, says Watson, "the illusion that all this is happening around you."

The over-all effect is so highly thought of that Sensurround received a special Oscar last week "for scientific or technical achievement" from the Academy of Motion Picture Arts and Sciences.

Each custom-designed theater installation is provided at a fee that Universal won't disclose. It includes a control unit, about three power amplifiers, and perhaps a dozen transducers. The amplifiers are standard products. About half have been 1,000-watt audio units supplied at $949 each by BGW Systems Inc., Culver City, Calif. □

Avionics

Costs threaten F-16, command post

Pentagon projections of further cost increases on two major Air Force programs—General Dynamics Corp.'s F-16 fighter and Boeing Co.'s E-4A Advanced Airborne Command Post—seem to be threatening the avionics systems of both. "Avionics is one of the few areas where costs can still be cut" by limiting system capability, according to Pentagon officials.

A Pentagon forecast that the F-16 program's costs would rise nearly 20%, to $8 million per plane when all R&D outlays are included, while unit production costs would jump to $5.6 million, was shown in March to a closed meeting of the Defense Systems Acquisition Review Council. However, the Air Force—apparently rejecting the DOD estimates—is holding to its figures of $6.7 million per plane for total program costs, and $4.7 million for flyaway-production costs.

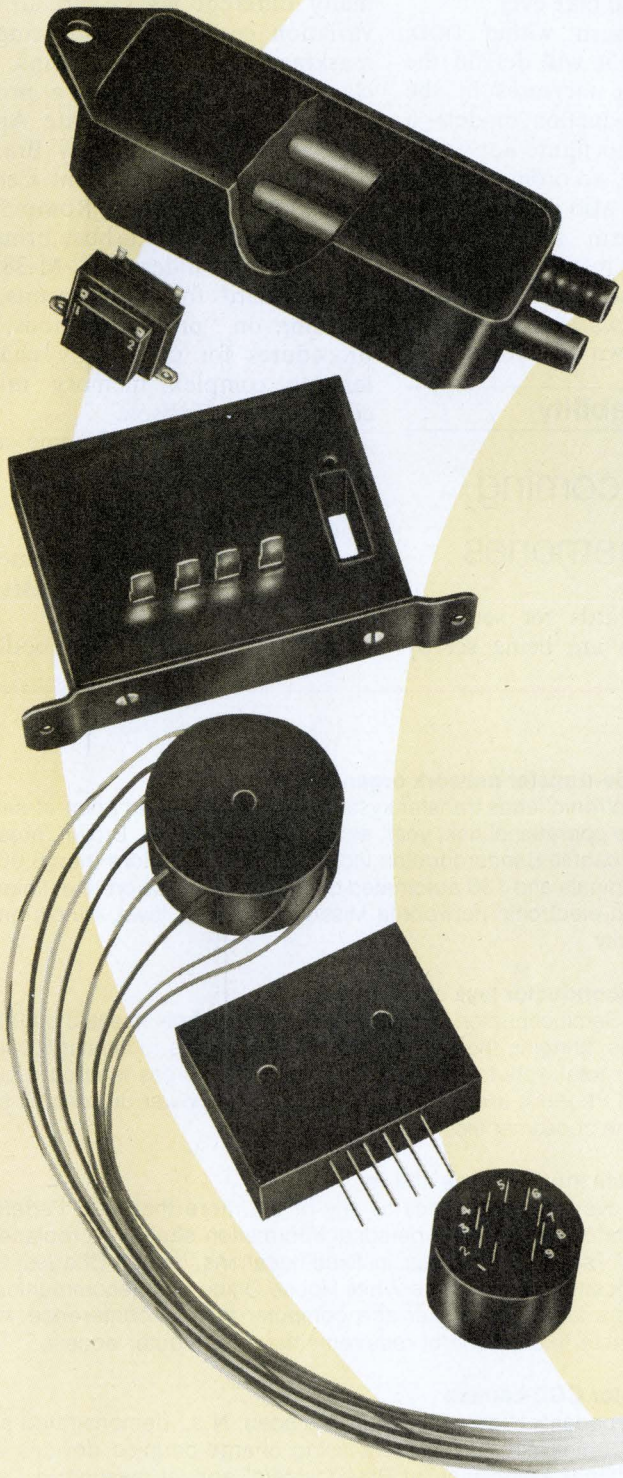
By contrast, the DOD production estimate of $5.6 million per plane for a procurement of 650 is not much less than the reported McDonnell Douglas Corp. offer of $5.8 million per plane for a version of its F-15 that surpasses the performance of the F-16.

The Air Force already is striving to hold down the cost of the proposed 750 pounds of avionics to roughly $1,000 per lb. The service has said, for example, it wants another round of bids for the fire-control computer and the inertial navigation system. GD initially proposed buying the computer from IBM Corp., ruling out competitors at General Motors' Delco Electronics division and Litton Systems Inc. For the inertial nav unit Litton was favored over Delco and Singer-Kearfott.

Early in April, Air Force Secretary John L. McLucas tried to spike reports of mounting F-16 costs at a Washington industry meeting. McLucas is not concerned merely with growing Congressional questions about the need for the new fighter—and the request for $273 million in R&D funds for fiscal 1976—but he is also watching for the pending decision of four NATO nations—Belgium, Denmark, the Netherlands, and Norway—on whether to buy the F-16 for their forces. DOD officials believe they will opt for the F-16 at a $6.1 million unit price plus guarantees of European production.

AABNCP changes. Cost problems at the Boeing Co. with its production of modified 747 transports for the Advanced Airborne Command Post, coupled with apparent Air Force uncertainty as to what communications gear is needed for seven airborne national command centers, has caused the Pentagon to anticipate sharp Congressional criticism. DOD will quietly drop from the July-Sept. 1976 transition-year budget the $193.6 million it wants for the last three planes.

At the same time, the service has replaced Brig. Gen. Lyle Cameron as AABNCP program chief in what



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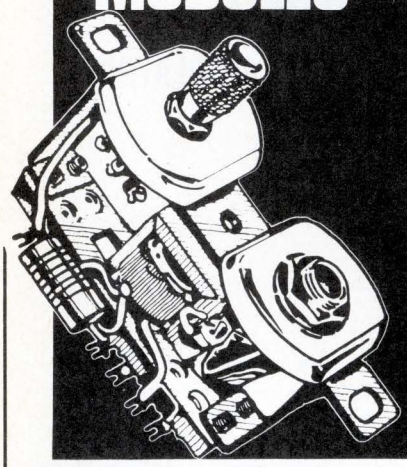
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Electronics review

one industry official described as "the first firing of a general officer as program director." Brig. Gen. Robert Foster, deputy director of reconnaissance and electronic warfare at the Aeronautical Systems division, Dayton, Ohio, will take over.

Of most concern within DOD, however, is how it will defend the most recent cost increases in the four existing production models—a multimillion dollar figure not yet finally determined, according to DOD analysts. There is also renewed Congressional criticism that the Air Force has been installing conventional and, in some cases, obsolete electronics hardware aboard the planes to hold down system costs. □

Reliability

Mil specs coming for chip memories

Reliability standards for semiconductor memories are being set by the Air Force, which by now is a major user of random-access and read-only memory chips in radar and avionics systems and elsewhere.

The devices, however, are configured, fabricated, and tested in many different ways, and all this variation could be introducing or masking reliability problems, declares James J. Dobson, a project manager in the Solid-State Applications Section, Reliability Branch, at Rome Air Development Center, Griffiss Air Force Base, Rome, N.Y. So his project group is busy bringing all the chips under MIL-M-38510, the standard for microcircuits, by deciding on "proper methods and procedures for electrically characterizing complex memory microcircuits," says Dobson.

The decisions should come soon, since the Rome Center this month is beginning to receive the results of studies by Macrodata Corp. and Hughes Aircraft Co. on parametric, functional, and switching tests for RAMs, ROMs, and PROMs.

Macrodata Corp. of Woodland

News briefs

Five-state funds-transfer network organized
A five-state electronic funds transfer system linking banks and point-of-sale terminals will be operational next year, according to James E. Brown, president of the Mercantile Bancorporation Inc., St. Louis, Mo. More than 6,000 merchange terminals and 130 automated bank tellers will be on-line, linked by a $40 million electronic network in Missouri, Kansas, Iowa, Illinois and western Kentucky.

Motorola Semiconductor lays off 900 more
Motorola Inc.'s Semiconductor Products division in Phoenix has laid off 900 more employees, bringing the division's worldwide layoffs to almost 8,000, out of an earlier total work force of 30,000. The cuts, across the board but concentrated in Phoenix, are heaviest in discrete and power devices hit by slowdowns in the consumer electronics markets.

Secure terminals must replace dial-in
Dial-in access over telephone lines to any of the more than 800 Federal computerized data banks storing personal information should be replaced by "clusters of [secure] terminals in fixed locations," says Charles G. Joyce, Jr., associate director of the White House Office of Telecommunications Policy. As a featured speaker at a computer-privacy conference, he warned of possible future Federal requirements on computer access.

RCA shows color CCD camera
RCA Corp.'s Broadcast Systems division, Camden, N.J., demonstrated an experimental 525-line color-TV camera using charge-coupled devices at last week's National Association of Broadcasters' annual meeting in Las Vegas. [*Electronics*, Feb. 6, p.39.] The camera uses one CCD for each of the red, blue, and green components of the picture.

Another technical knockout

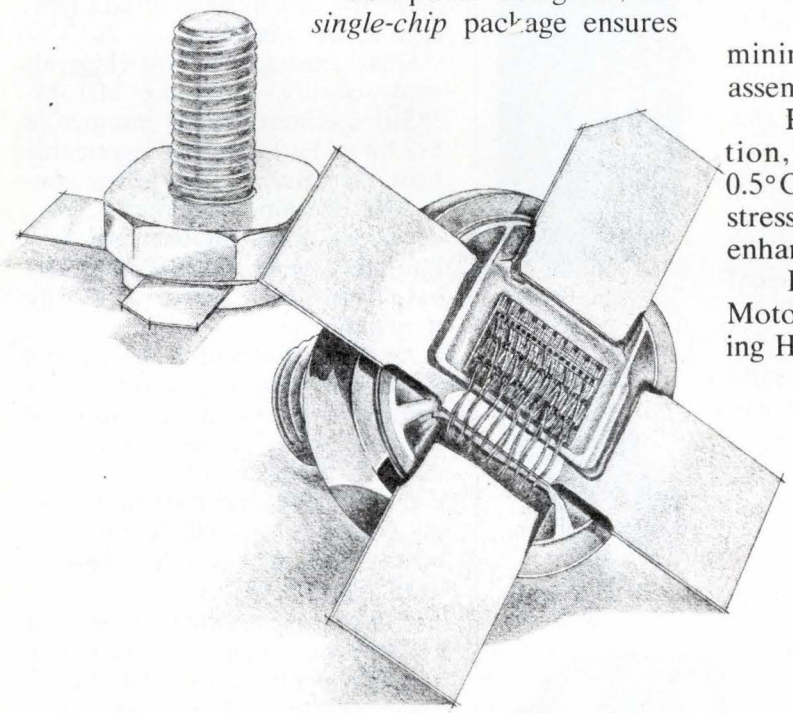
the first rugged, 50V, SSB device

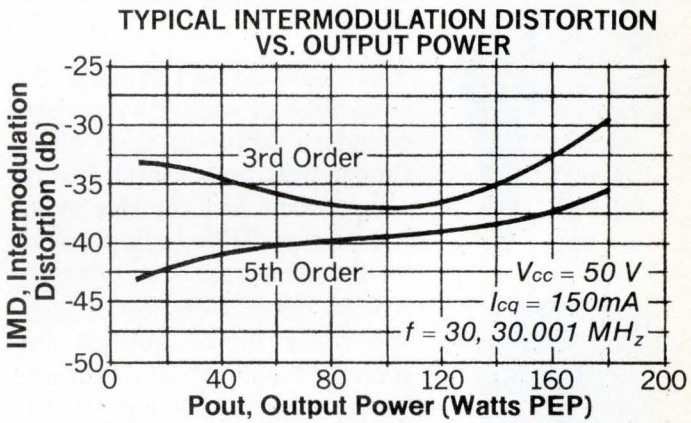
The biggest RF power chip — 150 W PEP — in production today now makes base station/marine linear amplifiers small enough to fit into one single desk top cabinet.

The MRF428 is state-of-the-art 50 volt V_{CC}... supply, drive and output stages for 1 KW SSB linear amps can now be single-unit designs. No more separate, outsized high-current power supplies.

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Computer-designed, the *single-chip* package ensures minimized die and wire bonding, controllable assembly techniques, ruggedness and consistency.





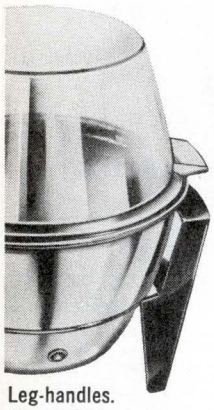
Performance runs out to 320 W power dissipation, 13 dB minimum gain at 150 W PEP and 0.5°C/W Θ_{JC} for excellent heat dissipation under stress. And cooler chips mean improved linearity, enhanced IMD.

Big is small now with the MRF428. See your Motorola rep for OEM applications help in building HV SSB radio. Be first with the first...

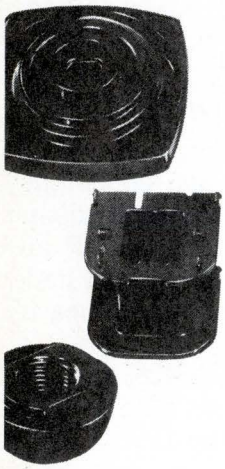
heavyweight

from Motorola, the RF producer.

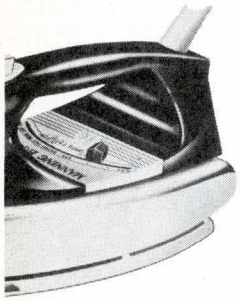
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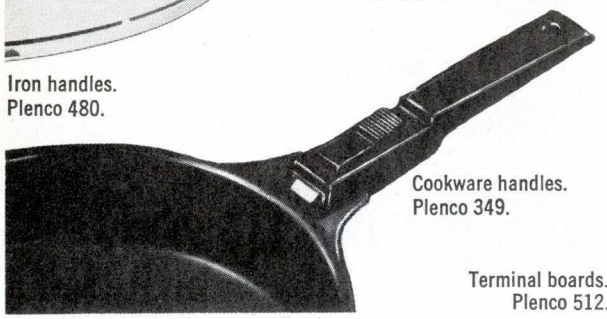
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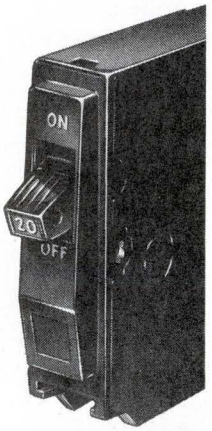
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Electronics review

Hills, Calif., is concentrating on bipolar and metal-oxide-semiconductor RAMs and ROMs. According to Dobson, the first MIL-M-38510 specification based on Macrodata's conclusions is already being prepared for a 256-bit transistor-transistor-logic RAM.

Macrodata is also writing standard terminologies for various memory timing parameters such as chip enable, chip select, and access and enable times. The functional tests for memories will be added to MIL-STD-883, which spells out basic tests to be conducted on microelectronic devices.

Necessary data. Hughes Aircraft in Culver City, Calif., has been developing the data necessary to prepare detailed specifications for PROMs under MIL-M-38510. Currently under investigation are 1,024-bit PROMs using three types of programing methods—nichrome fusible links, titanium-tungsten fusible links, and avalanche induced (damaged-diode) migration.

Some existing memory chips already qualify under the MIL-M-38510 specification—for instance, a 512-bit and a 1,024-bit programable ROM that Harris Corp.'s Semiconductor division, Melbourne, Fla., developed under military contracts. But other semiconductor suppliers have indicated a desire to qualify similar devices.

Another effort within the center's Reliability Branch, connected with neither the Macrodata nor the Hughes studies, is preparation of a military specification for a 4,096-bit n-channel dynamic RAM in an 18-pin package. This will be the military version of Texas Instruments' TMS 4050 4-k RAM.

A third project, says Dobson, is to evaluate the reliability of electrically alterable nonvolatile metal-nitride-oxide semiconductor memory-arrays. High-stress and life tests are to be performed on representative production devices from several MNOS-device manufacturers. Those studied so far are NCR Corp.'s 1105, a 1,024-bit ROM, and Nitron Corp.'s 7010, a 1,024-bit nonvolatile memory with an output buffer. □

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Motorola's M6800 family

Creates the new age for microcomputer systems design

The M6800 family is the first LSI family designed as a coherent modular building block approach to the implementation of microcomputer systems. From the deceptively powerful MC6800 Microprocessor to the byte-organized family memories, to the capability expanding peripheral and communications interface adapters, the M6800 family plays together as the total product solution for microcomputer designs.

Shared qualities place M6800 family in leadership position.

Family devices are all state-of-the-art high performance N-channel Silicon Gate units requiring only a single common +5 V power supply. All peripheral bus devices are directly bus and TTL compatible. Among the many notable family features are •Basic I MHz operation •Direct Memory Access capability •64 kilobytes of directly accessible memory in any combination of ROM, RAM, or peripheral registers •Bi-directional data bus and wide address bus •Simple yet powerful instruction set with enhanced addressing modes. Beyond all else, the family is distinguished by a set of intelligent programmable logic interface adapters for I/O communications requirements.

Meet the family members

MC6800 Microprocessor. The executive control and processing block of Motorola's total product for microcomputer systems is the 8-bit MC6800 Microprocessor. The MC6800 is fast establishing a reputation for performance and throughput based on varied factors, including •Simple universal bus structure, powerful programming modes, and interrupt handling features •16-bit address bus for direct address of up to 65,536 memory locations •8-bit bi-directional parallel processing on a three-state data bus. These features only scratch the surface. MC6800 is a super 8-bit MPU.

MC6820 Peripheral Interface Adapter. The totally unique PIA is a universal interface between peripheral equipment and the MPU bus. It's a flexible method, virtually without external logic, of connecting the MPU to status line or byte-oriented peripherals. The PIA features •8-bit bi-directional data bus for MPU communications •Two 8-bit bi-directional peripheral interface buses •Handshake control logic for input and output peripheral operation. The functional configuration of the PIA may be changed by the MPU during system operation.



A revolution is anticipated in word processing.

There's more, but just remember this. The MC6820 provides total programmable logic for complete I/O task management.

Memories designed for microprocessors

Another system advantage of the M6800 family is the set of byte-organized memories designed to maximize efficiency in many systems. Just as useful in some situations is the fact that non-family memories also fit in, usually without sacrifice. Here are the family memories.

MCM6810 Static RAM. This 128 x 8 memory is designed for bus-organized systems. It needs no clocks or refreshing. Memory expansion is achieved with six chip select inputs. Two versions are available. The MCM6810L-1 is faster, with an access speed of 575 ns (max). Access time of the MCM-6810L is 1 μs.

MCM6830 ROM. The MCM6830 also is byte-organized for application in bus-organized systems. It's a mask programmable 1024 x 8-bit ROM with a maximum access time of 575 ns. Expansion is achieved with four programmable chip select inputs.

Communications power

One distinctive advantage of the M6800 family in the new wave of serial data communications systems is the inclusion of the necessary interface devices and MODEMs in the basic family.

MC6850 Asynchronous Communications Interface Adapter. The ACIA provides the data formatting and control to interface serial asynchronous data communications information to bus-organized systems.

The ACIA includes control lines for direct MODEM interface and features •8-bit and 9-bit transmission •Odd, even, or no parity •One or two stop bits •Optional divide by 1, 16, and 64 clock modes.

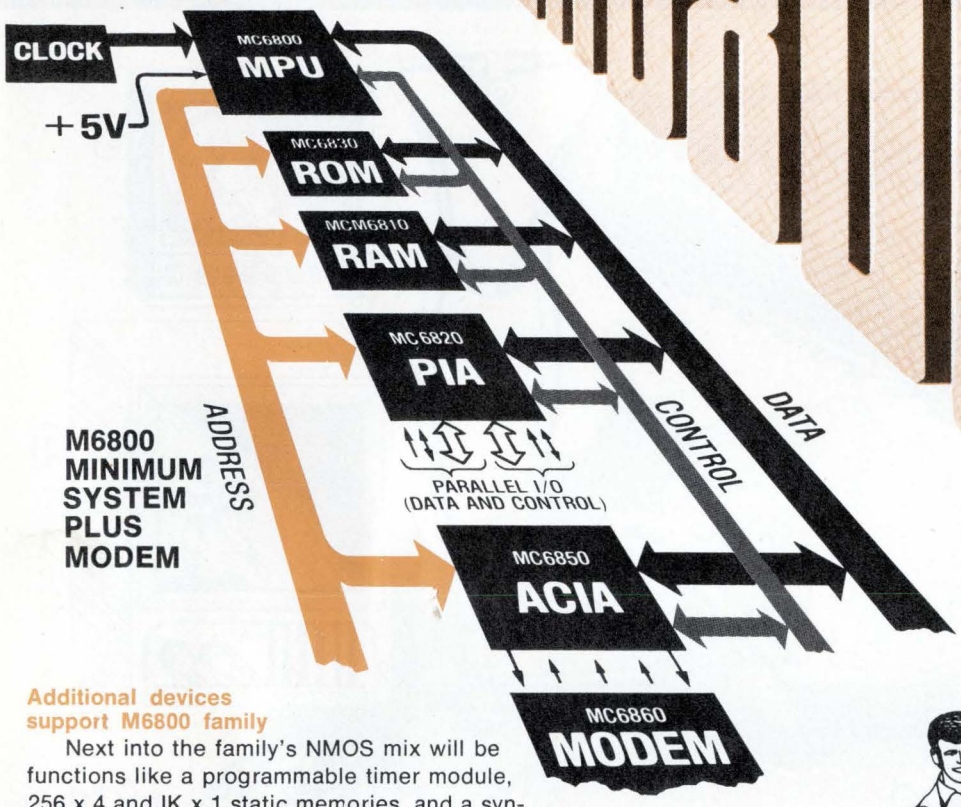
Functional configuration of the ACIA is programmed via the data bus during system initialization, using a control register programmed by the MPU. When all is said, the ACIA provides complete I/O task management for serial communications.

MC6860 MODEM. This 600 bps MODEM provides the necessary modulation, demodulation, and supervisory controls to implement a serial data communications link over a voice grade telephone channel.

The MC6860 offers compatible functions for 100 series data sets and 1001 A/B data couplers. Of course the MODEM interfaces directly with the ACIA in microcprocessor-based data comm systems.

M6800 family second source

Motorola has solved the alternate source problem of many engineering and purchasing managers by signing an agreement with AMI for a true second source, where we share similar processes and the same masks.



Retailers and their customers are taking advantage of MPU-based Intelligent terminals.



Consumers are beginning to see typical bookkeeping and control functions handled by microcomputer systems.



Additional devices support M6800 family

Next into the family's NMOS mix will be functions like a programmable timer module, 256 x 4 and IK x 1 static memories, and a synchronous serial data adapter. While the family includes memories, others are often desirable. Additional appropriate Motorola memories are the MCM6831 8K ROM, the MCM6832 16K ROM, and the MCM6815 dynamic 4K RAM.

Motorola's Linear products group has designed a new family of interface functions around the memories and MPU family, and our CMOS people have come up with supplemental functions including a bit rate generator available now, and a new RAM and Tone Encoder on the way.

M6800 Software and Hardware Motorola's M6800 support software is a cohesive, interactive system for program development and checkout available on both G. E. and United Computing Service timesharing. A Fortran IV source deck cross assembler for 16 and 32-bit machines is available for customer host computers.

Hardware system development tools are the MEC6800 Evaluation Module, a complete minimum microcomputer system on a single board with RS232 interface, and the EXORciser*, a system prototyping minicomputer complete with power supply and functional board options.

Other diverse support activities include a three-day technical design seminar in Phoenix and major U.S. cities throughout '75.

What it's all about: Simplify design, reduce costs!

All this distills to the simple idea that the M6800 family system architecture is designed to achieve •Minimization of components •Minimization of support packages •Interface simplicity •Minimization and simplicity of power requirements •System throughput.

There's a Motorola salesman ready to help you keep up with the leaders . . . and ahead of the rest. Get more detailed information by writing to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036. Discover why the M6800 family creates a new age as the standard against which all others must be measured: Why M6800 is now the benchmark family for microcomputer systems.

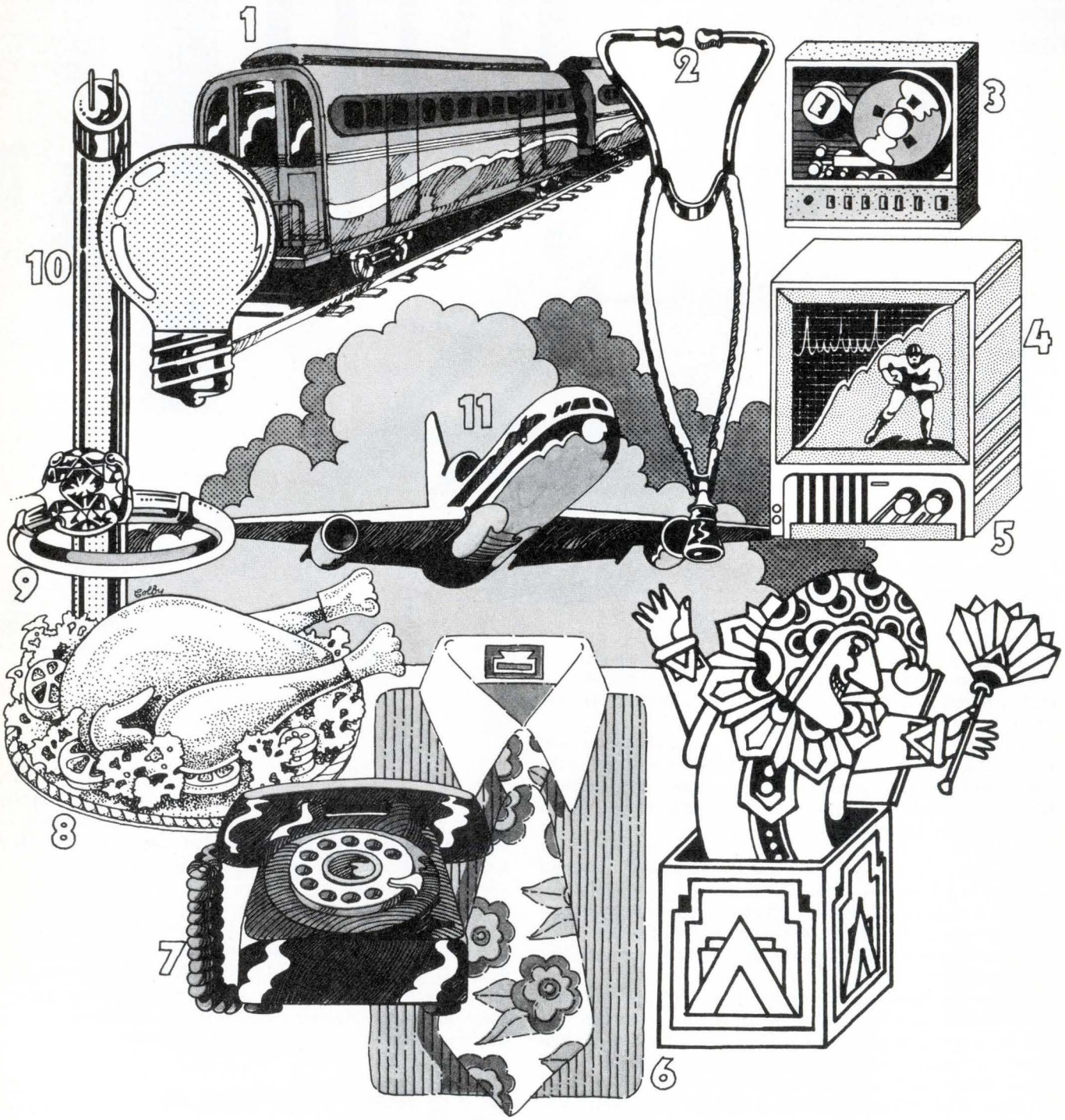
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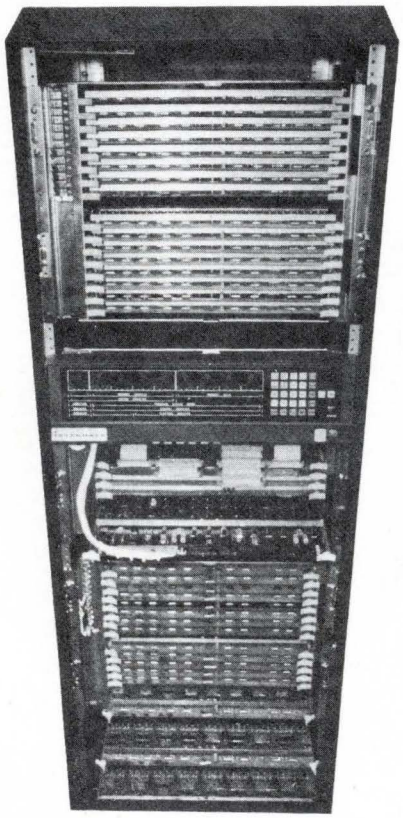
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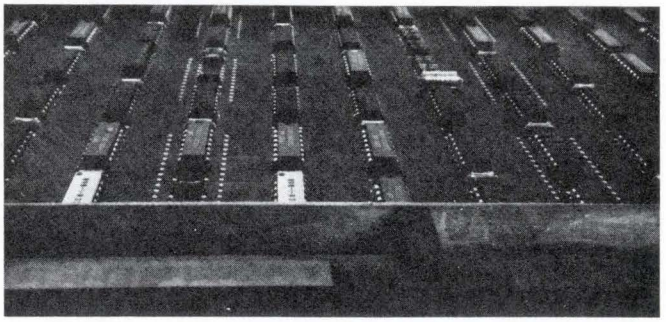
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WORD LENGTH	32 bits	32 bits	32 bits	16 bits	16 bits
INSTRUCTION TIMES (Register to Memory)					
Integer Add	1.25	1.8	.9	1.8	2.5
Multiply	3.54	6.2	2.0	3.9	8.8
Divide	5.8	14.4	9.9	8.3	11.2
Floating Point Add	2.3	6.1	2.4	8.25	5.5
Multiply	3.0	9.1	2.3	11.25	7.2
Divide	5.35	23.3	8.9	12.25	7.9
HARDWARE I/O	Yes	Yes	Yes	No	No
MAX. DMA RATE/SECOND	6MB	4MB	6.7MB	4MB	2MB
DIRECT ADDRESSING RANGE	1MB	1MB	16MB	64KB	64KB
GENERAL PURPOSE REGISTERS	2 stacks 16 each*	4 stacks 16 each	1 stack 16 each	2 stacks 8 each	1 stack 4 each
PRICING (Basic Configuration)					
CPU + 128KB Memory	$51,900	$128,700	N/A	$54,600	$44,500
CPU + 1048KB Memory	$179,400	$478,700	$1,905,700	$163,800	N/A

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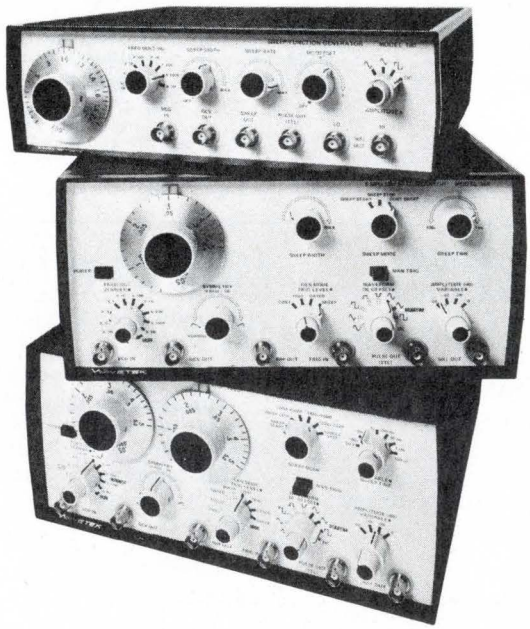
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The Model 184 Sweep Generator $495

The 184 has all of the above, plus some other features that you wouldn't expect for the price. First of all, the 184 goes all the way up to 5 MHz, and provides continuous, triggered and gated operation. For precise adjustment of continuous sweep, there's a control to individually set start and stop points. There's also a variable symmetry control and another for amplitude—down to −60 dB. Like the rest of the instruments in this series, the 184 comes in a tough, lightweight package.



The Model 185 Lin/Log Sweep Generator $595

As you can see, the 185 has two frequency dials, which give you the ultimate in precise sweep start/stop settability. Now you can sweep up or down the frequency range, which goes from 100 μHz to 5 MHz with continuous and triggered ramps or discrete steps. Like the 184, this model has continuous, triggered and gated operation. Of course, there are both linear and logarithmic modes, and log sweep width is an incredible 100,000 to 1.

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WAVETEK®

Washington newsletter

Low IC yields slow Trident missile program . . .

Within a month after Lockheed Missiles & Space Co. got a $1.3 billion Navy prime contract last August to develop and produce the Trident I submarine-launched missile, the company moved to substitute junction-isolated integrated circuits for the more radiation-resistant dielectrically-isolated ICs originally specified. This was disclosed by the General Accounting Office in a classified report to Congress, portions of which were disclosed in April. **Unacceptably low yields of dielectrically-isolated ICs being developed by Motorola Semiconductor Products division and RCA Corp.** for the long-range missile, GAO charged, led Lockheed to award Texas Instruments a $1.4 million sub-contract for paralled production of junction-isolated circuits to substitute for five of 13 ICs in the missile's ignition and guidance and control subsystems. TI is expected to remain in the program until problems with the Motorola and RCA circuits are resolved, according to the GAO. Cost of the paralled IC production is estimated to add at least $4 million to the troubled Trident program.

. . . but Motorola says it's working on remedies

The Navy acknowledges that production of the new missile, which is also experiencing booster engine problems, has slipped at least six months, to 1979, although the service claims that "the engineering problems were not unexpected" because of the advanced technology involved. Patrick J. Lynch, vice president and general manager for U.S. operations at Motorola Semiconductor Products division, **admits to unspecified difficulties in making some of the devices, but insists that remedies are being made** and that the division is still the major supplier of devices for these systems to Lockheed, "and we intend to remain a major supplier." RCA has declined comment.

GAO contends the program is already into cost overruns and will need $66.1 million more in fiscal 1976 RDT&E funds, a 9% boost in the budget request. But the investigators argue that the program slowdown could cut production money sought in the new budget by 46%, to $126.3 million.

Burroughs given 60 days grace on ARTS II units

The Burroughs Corp., Paoli, Pa., has won an extra 60 days to deliver the first of 73 automated radar terminals for medium-density airports. June was the month originally slated for delivery [*Electronics*, June 27, '74, p. 29]. Officials of the Federal Aviation Administration say the FAA granted the company's request for an extension because of "proprietary" technical problems in the $7.6 million project. Burroughs officials deny any production problems. The market for medium-density air traffic control systems is expected to be world wide.

Focus shortens in rail research

Budget cuts are forcing a change of emphasis in R&D at the Federal Railroad Administration, an agency of the Department of Transportation. **"Magnetic levitation and other advanced systems work will be going into hibernation" in favor of ways to improve existing systems,** says an FRA spokesman. The immediate impact of the shift, the spokesman suggests, is that the Ford Motor Co. and Rohr Industries Inc. will lose $5 million in contracts already negotiated for brassboard development of magnetic levitation and associated electronic systems. Approximately $20 million in prototype contracts that were expected three years hence have been postponed indefinitely, says FRA.

Washington commentary

The politics of foreign military sales

Regrettable as it may be for the United States, the truth of Gen. George Patton's 1944 axiom that "to win battles you do not beat weapons—you beat the soul of the enemy man" appears to have been demonstrated once more by the Khmer Rouge, the Viet Cong, and the North Vietnamese in Indochina. Fortunately for the U.S. trade balance, however, the message has yet to be heard in the nations of the Middle East, which are leading contributors to the steadily rising U.S. overseas sales of weapons and military electronics.

While new Pentagon figures project a fiscal 1975 decline of about $1 billion in foreign military sales from last year's record, the $7.2 billion forecast is still very big business. When the first nine months of the fiscal year ended in March, the U.S. had already recorded $5.4 billion in system sales to 63 countries. The totals—which do not include aid programs to such U.S. dependents as South Vietnam—have been rising steadily in recent years, particularly since the U.S. began employing weapons sales to Iran and the Arab states of the Middle East as a means of recouping some of its dollars spent on oil. Iran alone accounted for $1.9 billion of this business, with Saudi Arabia a close second at $1.1 billion. After Israel's $812 million, the dollars spent by individual nations drop sharply, with Kuwait fourth at $331 million.

Congressional controls

The newly activist 94th Congress has sensed a new political issue in the weapons systems exports. And Sen. Gaylord Nelson (D., Wis.), with the support of 12 colleagues, has introduced a bill (S. 854) that he says "would give Congress the opportunity to evaluate in advance and set guidelines for the U.S. foreign military sales program." The bill, certain to affect military electronics sales overseas if passed, would require the President to submit to Congress an annual report forecasting country-by-country sales by dollars and by types and numbers of major systems in the coming fiscal year. Congress would be empowered "to set guidelines for, place restrictions on, and/or make additions to" the proposed plans.

The Nelson bill generated little interest when proposed. But with President Ford's recent criticisms of Congress' failure to live up to alleged U.S. moral commitments in Vietnam, the picture is changing. As one staffer for the Senate majority put it, "If we're going to take the rap, we might as well have the responsibility."

Neither the Pentagon nor its contractors are happy with the Nelson bill, although some Government and industry sources see the need for some controls on what has become an unusually flexible U.S. policy on foreign system sales. "All we are governed by now is greed and fear," said one senior vice president of an electronics countermeasures producer at a recent Washington seminar. "We are greedy because we need the money for the payments balance and to offset our own costs. What we fear is that if we don't make the sales, someone else will. That's admittedly somewhat oversimplified, but it summarizes the problem."

A new visibility

Foreign military sales are unpopular at best with the general public, and contractors maintain low profiles whenever the subject arises. Thus are they concerned that any law derived from the Nelson bill would not only increase their visibility, but also bring into view the related "technical assistance" contracts that necessarily follow systems sales. These awards cover the costs of equipment maintenance and the training of foreign military personnel to operate and repair U.S. systems.

Technical assistance contracts are highly lucrative to U.S. suppliers and usually extend over several years. In Iran, for example, the biggest of the 25 such contracts now in effect is Bell Helicopter Co.'s 44-month program to train 1,500 helicopter pilots and 5,000 mechanics and to develop a logistics system and depot overhaul facility. The pricetag: $255 million.

The issue of foreign military sales is not peculiar to America by any means. The Soviets have been in the business for some time, and the French and British have found it profitable as well, especially in South America. There the U.S. lost much of the available market early in the decade when its military systems export policies were much more rigid. Indeed, it is the French and British that the U.S. views as its chief competitors in the world marketplace, which now accounts for 10% to 12% of U.S. military electronics sales overall.

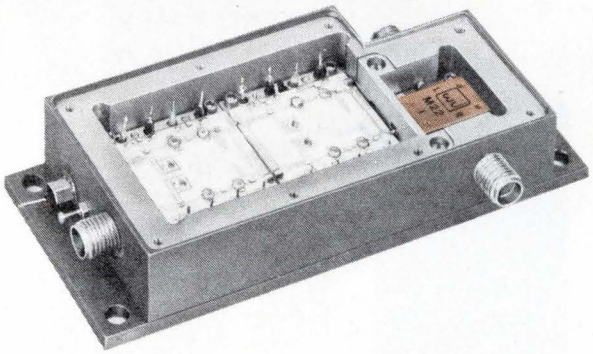
It also represents a segment of the U.S. electronics business that is certain to receive increasing exposure in the Congress and thus generate increasing public interest. The electronics industries should be aware of this and quickly come to recognize they are dealing now with something more than just another market. They must be prepared to discuss and defend their positions on an issue fraught with moral and political implications. **—Ray Connolly**

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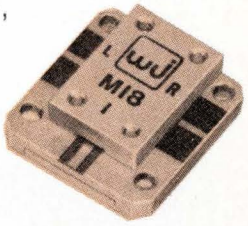
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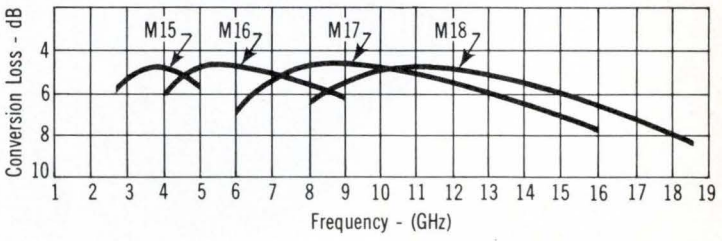
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Circle 51 on reader service card

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TEXAS INSTRUMENTS
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Circle 52 on reader service card

Heterojunction-gate FET shows promise in integrated circuits

Consumer receivers for 12-gigahertz satellite TV transmissions promise to be a big business in the not too distant future. At present, though, not only is there no hardware that the consumer could possibly afford, there aren't even any inexpensive components to build the hardware.

However, engineers at Matsushita Electronic Corp. are preparing for the day when services on the new band start up. They are developing a new type of microwave heterojunction-gate gallium-arsenide field-effect transistor. It promises to be simple to make and have better characteristics than previous microwave FETs. Matsushita Electronics, a subsidiary of Matsushita Electric Industrial Co., Japan's largest TV manufacturer, is a joint venture with Philips Gloeilampenfabrieken.

Easier fabrication. The new FET requires one mask step instead of the two required for devices using Schottky-junction gates. The processing, which produces active regions that have tighter dimensions than the lines in the masks used for etching, is based on selective etching and self-alignment.

The small dimensions of the gate are a major reason that the characteristics of the new devices should show improvement over those of present devices. Wider band gap for the heterojunction, compared with a Schottky junction, is another reason. When operated with reverse bias on the gate diode in the depletion mode, which is normal for junction FETs, gate leakage current for the heterojunction-diode gates is smaller, and maximum operating temperature is higher.

However, the wide band gap allows the gate to be operated at moderate forward voltages with low levels of leakage current. This should permit development of enhancement-type junction FETs.

Processing starts with a semi-insulating gallium-arsenide substrate on which is grown an n-type gallium-arsenide vapor-epitaxial channel layer. Next, the p-type $Ga_{0.5}Al_{0.5}As$ gate layer is grown by liquid-epitaxial techniques. Titanium, which forms the mask and ohmic contact to the gate, is then evaporated over the entire surface.

Normal photolithographic techniques are used to etch the titanium. However, the gate region is etched by a 1:1 mixture of hydrochloric and phosphoric acid, which selectively etches only the GaAlAs. Etching speed is quite slow—about 0.3 micrometer per minute—which permits fabrication of a 1-micrometer-wide gate region under the 3-micrometer titanium layer which forms the contact.

The final steps are self-aligned, with the titanium acting as an umbrella. First, ohmic contacts for the source and drain are produced by vapor deposition of gold-germanium and gallium-arsenide alloy. The layer formed above the titanium base contact neither enhances nor degrades device operation. Then comes an aluminum metalization. □

Around the world

Now carburetors go electronic

While many auto makers are looking to replace carburetors with fuel-injection systems, Britain's Zenith Carburetor is using electronics to upgrade carburetor performance. It is both developing special sensing carburetors and installing electronically controlled test equipment to fine-tune production carburetors. The company has a big interest in carburetors because it is part of the French Solex group, a leading carburetor maker.

The sensing carburetor is essentially a simple feedback loop. It uses a zirconium dioxide sensor in the exhaust manifold to detect the percentage of oxygen in the exhaust gas. After processing, its signals drive a small dc stepping motor, which controls an air-bleed orifice. That orifice, in turn, controls the fuel-metering orifice.

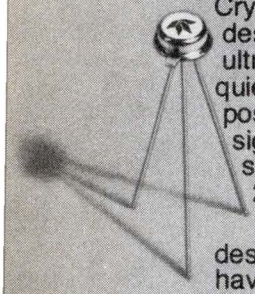
Since a production carburetor needs some 200 different matching operations for its about 150 fairly complex parts, a unit can get out of whack even before it leaves the factory. To combat this, Zenith is installing six semi-automatic test benches, worth about $1.2 million, designed by the company. Unlike old machines, which used fuel, the new units are safer because they only use air to measure both fuel and air flow.

TV gear adapts to TV-phone jobs

Video-telephone communication is getting closer as researchers find ways to cut system costs. One item that should make a big dent in those costs is a line-scan conversion unit being developed at the Philips Research Laboratories in Eindhoven, the Netherlands. Built around charge-transfer devices, the unit allows existing TV broadcast and receiving equipment to be used for video-telephone service.

The charge-transfer devices are the key components in a circuit that converts the 625-line, 25-frame-per-second signal used in European TV broadcasting to the 313 lines needed for telephone-unit screens. The circuit can also convert the 525-line, 30-frame-per-second signals of the American TV standard to 263 lines for such applications. This divide-by-two conversion system is part of the Philips-proposed standard, which both international standards officials and Bell Laboratories in the United States are favoring for world-wide adoption, according to Philips.

Noise at the front-end of an otherwise tight low frequency design is terribly frustrating. And we don't blame you for sounding off if you want to specify for lower noise and can't come up with an FET to suit your purpose.



Crystalonics new 2N6550 is a silicon, N-Channel, junction FET designed for low frequency amplifier applications, with an ultra low noise figure of 2n V/$\sqrt{\text{Hz}}$ at 1 KHz. You won't find one quieter! This device is designed to produce the cleanest signal possible at the front-end, for pure follow-through and ultimate signal clarity, so critical to military field communications. It's as silent as current technology allows, and with Crystalonics' 2N6550, you'll note a marked improvement in your prototype.

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Circle 54 on reader service card

Thomson-CSF seeks Canadian telephone technology. . . .

Another contender is planning to join the scramble for the French electronic telephone-switching market of the next decade. Thomson-CSF, France's biggest electronics manufacturer, is negotiating a technology license with Canada's Northern Electric. The deal would take the French company into the fast-growing PABX market using Northern's P-1 space-division techniques. It would also prepare the ground for a subsequent push into the public switching market controlled by the French postal and telecommunications ministry.

If the deal goes through as expected within the next few weeks, it will cause quite a stir in France. The move comes less than six months after the break-up of a market-sharing deal with Compagnie Generale d'Electricité that has kept Thomson out of the switching business up to now. Meantime, CGE has been the leader in electronic systems with its Platon E-10 system.

But inflation and budgetary problems have killed off CGE's hopes for an early take-off this year for electronic switching on France's public telephone network. And, as government aid for further development of the Platon system slows down, both Thomson and ITT's French subsidiaries are lying in wait with their North American-developed technologies to grab the lion's share of the urban switching market when it does take off in a year or so. **CGE is counting on a top-level government meeting late this month to result in the injection of fresh funds** into the development of a 50,000 line transit-exchange system, code-named E-12, that CGE is also aiming at.

. . . and moves further into market for broadcast equipment

Thomson-CSF has moved, too, to strengthen its already-solid export position in broadcasting equipment. **The French company has bought up the studio-equipment department of CBS Laboratories.** The department, now dubbed Thomson-CSF Laboratories Inc., did $4.5 million of business in 1974, and Thomson-CSF expects to boost the figure to $10 million this year, partly through sales of its own hardware. And the French firm is pushing ahead with technology to cement its niche in broadcast equipment. **An experimental TV camera using a 64-by-128-element charge-coupled-device matrix as the image sensor turned up on the Thomson-CSF stand** at the Paris Components Show earlier this month.

Japan's sales trend takes a downturn

With sales forecast at $13.8 billion, Japan's electronic industries can expect a 2% drop in factory sales this year, according to a forecast made by the Electronics Industries Association of Japan. Last year's growth, in contrast, was 5.8%. **The hardest hit will be makers of passive components, which will be down a whopping 21.9%, after slipping 1.3% last year.**

The one bright category is professional and industrial electronics, which should be up 13.8%. Last year, however, sales of these products had increased by 20.4%. Consumer electronics will be down 1%, compared with a growth last year of 3.6%. Electronic devices, including tubes, discrete semiconductors, and integrated circuits, will show a drop of 13.8%, compared with last year's slide of 3.4%.

International newsletter

Italy moves to adopt PAL color TV; Spain's decision near

The endorsement by an Italian government technical committee of West Germany's PAL color-TV system for the state-run RAI network, just about closes the book on a long, largely political saga. **That endorsement must be ratified, but the government's committee for economic planning is expected to approve it this month.** The PAL system was competing with France's Secam, which has been adopted by the Soviet Union and other East Bloc countries, and with a never-fully-developed Italian system. Thus Italy will join the bulk of Western Europe and the other nations that have opted for PAL. **RAI technicians, thanks to five years of experimenting while the political battles raged, believe they can make the necessary hardware modifications and be on the air in color by early in 1976.**

Meanwhile, Spanish officials, under pressure from domestic set makers who see color TV as a way to revitalize their hard-hit industry, have announced that a decision between PAL and Secam is near. The state-run network is already broadcasting pilot shows—using both systems. Given Italy's move, PAL seems to be in the lead. **What's more, two years ago Spain tentatively selected PAL, but postponed an official adoption pending a decision by the Italians.**

London paging system signals large UK market

The British Post Office plans for a London-area radio-paging network covering up to 100,000 users could mean an approximately $30 million market in paging units. What's more, there's a potential national market many times that. **Now evaluating proposals for the first London stage, the BPO is likely to award contracts in the next several months for the first 20,000 units.** Among the suppliers vying for the orders are Motorola, Multitone, Pye Telecommunications, and Redifon, licensee for Martin Marietta's pager. **Industry estimates for the national market vary from 400,000 to 1 million potential subscribers**—should the BPO call the London system successful and implement the nationwide system now under study. The London net will go into operation in 1976 following a successful 2,000-unit trial in Reading underway since February 1973.

French company shows 0.77-inch LED display

RTC-La Radiotechnique Compelec expects later this year to start sampling a gallium arsenide phosphide seven-segment display standing 0.77 inch high. **The exceptionally large display uses only a single crystal slice per segment and emits red light at 6,500 angstroms.** The luminous intensity is 0.2 millicandelas at 20 milliamperes. RTC, part of the Philips group, plans to have the displays in industrial production by 1976. They will be priced initially at around $3 each in quantities of 1,000 up.

Plessey announces SAW filters for color-TV sets

Spurred by Thomson-CSF's announcement that it would begin producing intermediate-frequency filters using surface-acoustic-wave techniques for color-TV sets, Plessey Semiconductors also will go into production with SAW filters for that market, it announced at the Paris Components Show. **Like Thomson's devices, Plessey's are made on a lithium niobate substrate, have comparable insertion losses—13 decibels vs 15–20 dB for Thomson-CSF's—and will cost about $1.50 in production.** But, Plessey claims that its computer-aided design program will enable it to make SAW filters for PAL, Secam, and U.S.'s NTSC TV systems.

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IP/SP-2711	Digital	30 V	3.0 A	$219.95 kit $340.00 assem.
IP/SP-2720	Analog	15 V	5.0 A	$169.95 kit $255.00 assem.
IP/SP-2721	Digital	15 V	5.0 A	$219.95 kit $340.00 assem.
IP/SP-2730	Analog	7.5 V	10.0 A	$169.95 kit $255.00 assem.
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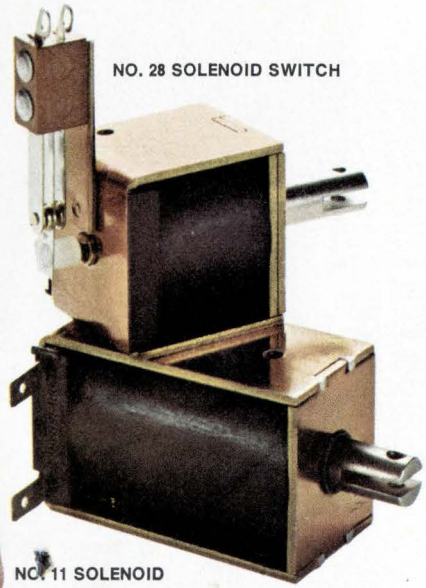
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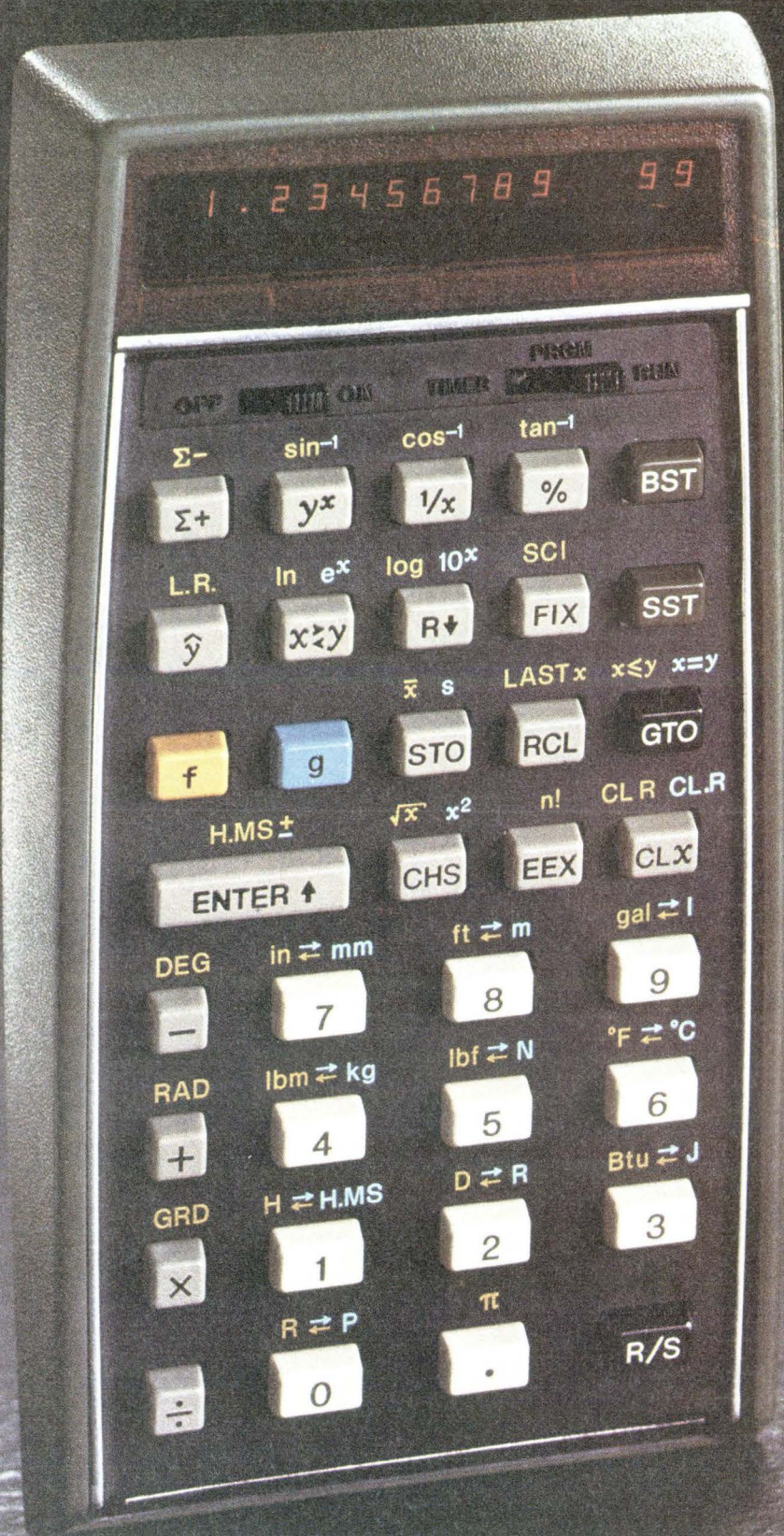
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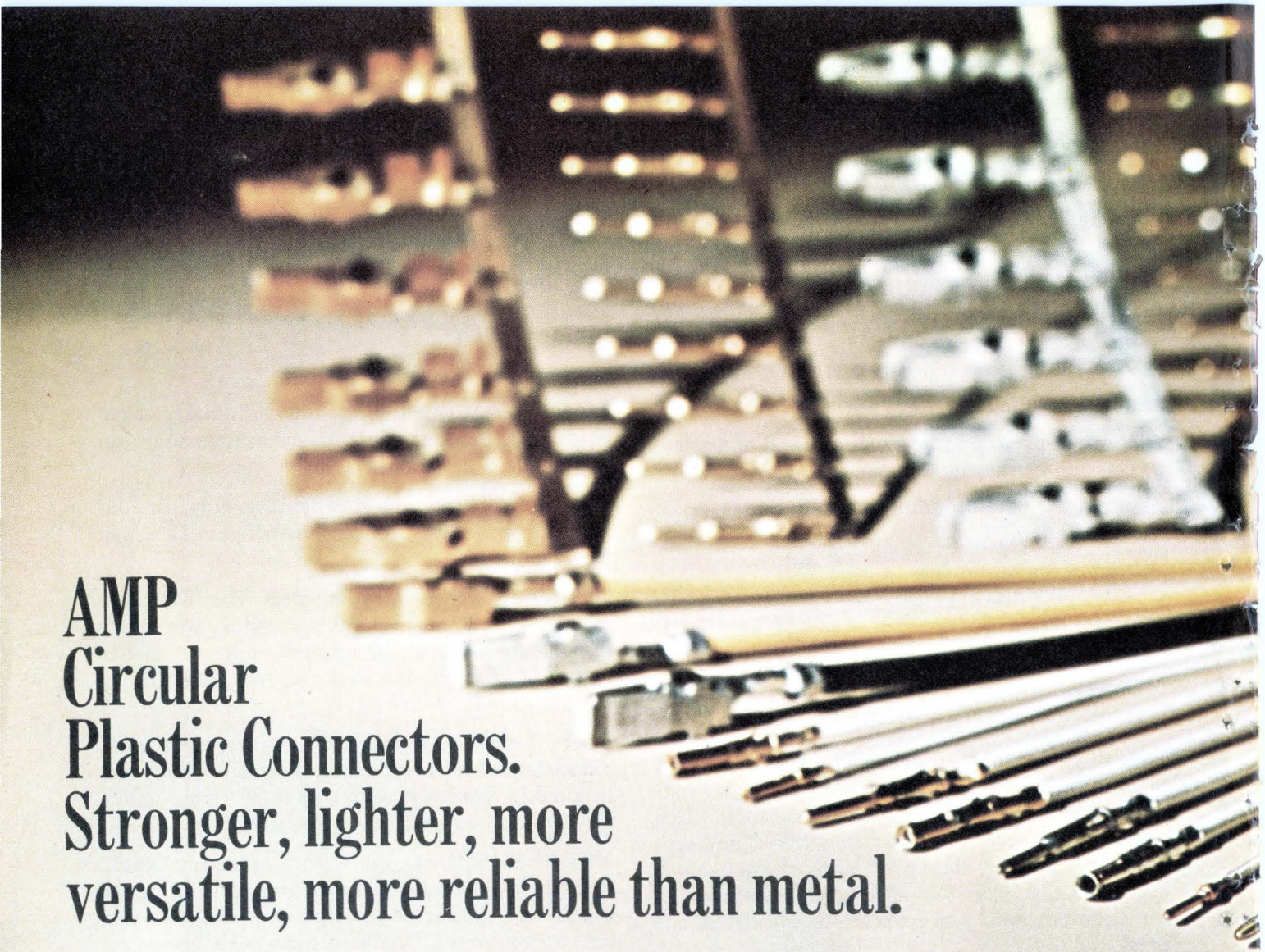
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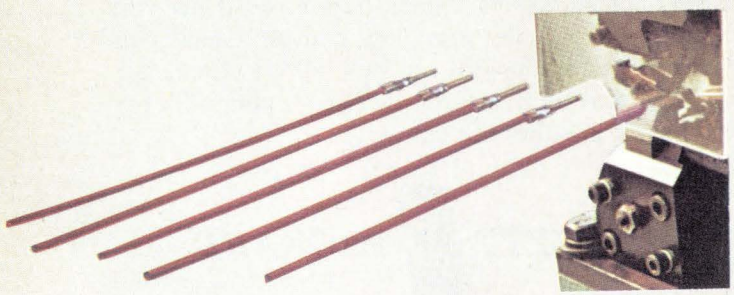
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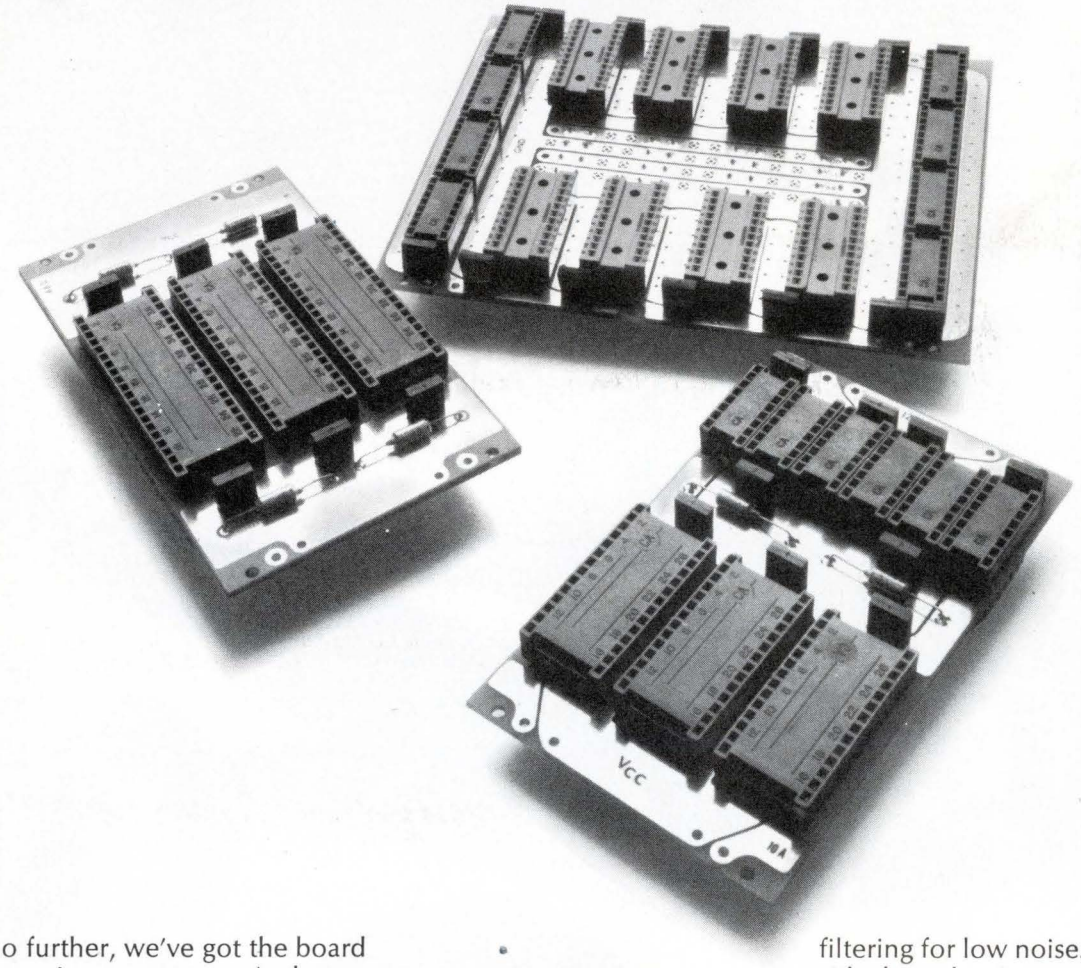
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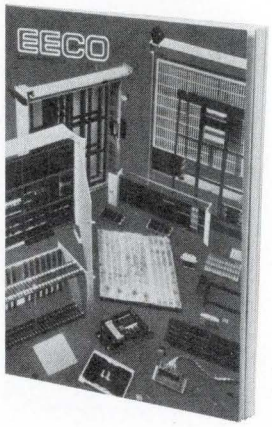
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Fairchild's view: 'a new era' in semiconductors

Corrigan assesses challenges and payoff in technologies from microprocessors to CCDs

The shifting sands of technology and competition in the semiconductor business seem to demand leadership that combines the savvy of a riverboat pilot and the foresight of a commodities trader. Even the biggest manufacturers, like Fairchild Camera & Instrument Corp., have not always read the currents accurately, but they would not be where they are today without having played the futures market to good advantage most of the time.

According to Wilfred J. Corrigan, president of Fairchild, a whole new raft of technologies, applications, and concepts is "moving us into a new era in which none of us is completely comfortable." But the company is plotting a course, and to further assess the thinking at Fairchild, the editors of *Electronics* recently put a number of questions to Corrigan, emphasizing the semiconductor operation's newer technologies.

Q: You've been slow in getting into MOS. What's the status of your MOS effort?

A: This has been a perennial thorn in our sides. In fact, I look upon that as one of my immediate tasks—to get us established in that business. I feel pretty good about all the other segments of the marketplaces in which we operate. I think today that Fairchild is perhaps the broadest of any semiconductor manufacturer. Our thrust in MOS over the past few years has been to move into mainstream standard products. We took quite a gamble going into Isoplanar technology both in p- and n-channel, but it's beginning to pay off, first with our recently introduced F8 microprocessor. Our n-channel 4-k RAM will be right behind it, so I think we've demonstrated the applicability of Isoplanar to MOS after proving it first in bipolar memory products.

Q: Your Wappingers Falls [N. Y.] plant seems to be getting into action pretty slowly. Is that because of the economy, or are you encountering problems?

A: Well, you've got the economy, and you've got the fact that it's a start-up situation. We focused it on n-channel products, and we're bringing in a new process, and also bringing out new products at the same time. Things like the F8 microprocessor, the 4-k RAM, 1-k RAM products—they're all coming out of Wappingers Falls. We're very pleased with the progress we've

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Probing the news

made there over the last nine months.

Q: Let's talk about some of those new products. First, what about microprocessors?

A: Well, we're very excited about our F8. We expect that to be the first of a family of microprocessors. It's an n-channel product, using the Isoplanar n-channel technology.

Q: When will you be out with a 4-k RAM?

A: The 4-k will be with us in the second quarter. We think our 16-pin approach is more effective than approaches with more pins. A very significant thing that's happening with the 4-k is that several customers seem to be designing development boards so they can move either way, attempting to avoid the second-source problems we've had on earlier products. So I think we'll see in the 4-k market that the question is not whether one product will win over the other; it's a matter of what share of the 4-k market the 16-pin, the 18-pin, or 22-pin will get.

Q: What factors will swing that one way or the other?

A: You're going to have the straight cost of the part. Then you're going to have things like pattern sensitivity and reliability. If somebody uses a lot of 4-k parts, he's going to have a lot of memory and he's going to be most concerned about quality and what it means to his system.

Q: Are you working on I^2L?

A: Yes. I think this is going to be an extremely important technology. We refer to it as I^3L (for Isoplanar I^2L). This year we will be announcing several products.

Q: What's happening in CCD?

A: The sales of the camera have been modest. We developed the camera as a demonstration medium, to show what could be done. The memory application, though, is more interesting and has potentially more volume. We just announced a 9,000-bit memory. Right behind that we have a 16,000-bit memory, and you can visualize an even larger memory of 32,000 bits. We've had a lot of interest, but we haven't had anyone give us a major order yet.

Q: As far as you know, has anyone designed CCD memories into equipment?

A: They have been designed into equipment, but that's as much as I can say.

Q: How fast do you see the CCD market developing?

A: I think it will take commitments from a couple of major customers or maybe even minor customers with major applications. It's going to take some customers to demonstrate a big cost advantage or big performance advantage or an application that can't be handled any other way. Once that happens, things will really start to roll. I think we might see something like that happening in the next couple of years. Then there's going to be a rush.

Q: You recently announced a move into the watch business. What are the details?

A: We are participating heavily in components for the watch, so for us this is a natural evolution. We'll be making and selling displays, watch circuits, watch modules, and watches.

Q: Do you plan to sell a watch under the Fairchild name?

A: Yes. We haven't specified exactly how we'll sell it. Announcements will be made in the second quarter.

Q: Do you make all the watch components?

A: We don't make quartz crystals. We will be buying some components, depending on the range of watches. We have not put any limitations on the Optoelectronics Division, which has the charter to make the watches. They can buy at their option. These are LED watches. Right now we don't have any plans on the liquid-crystal-display watches.

Q: Do you have any customers now for your modules?

A: Yes, but I can't say who they are. This is a highly competitive business.

Q: What's your view of the automobile electronics market?

A: We're not discouraged despite the seatbelt interlock business going away. Through the vehicle of the seatbelt interlock, automotive engineers have satisfied themselves that semiconductors were reliable enough for the automobile. That was an important thing to have es-

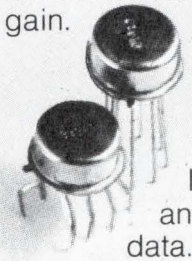
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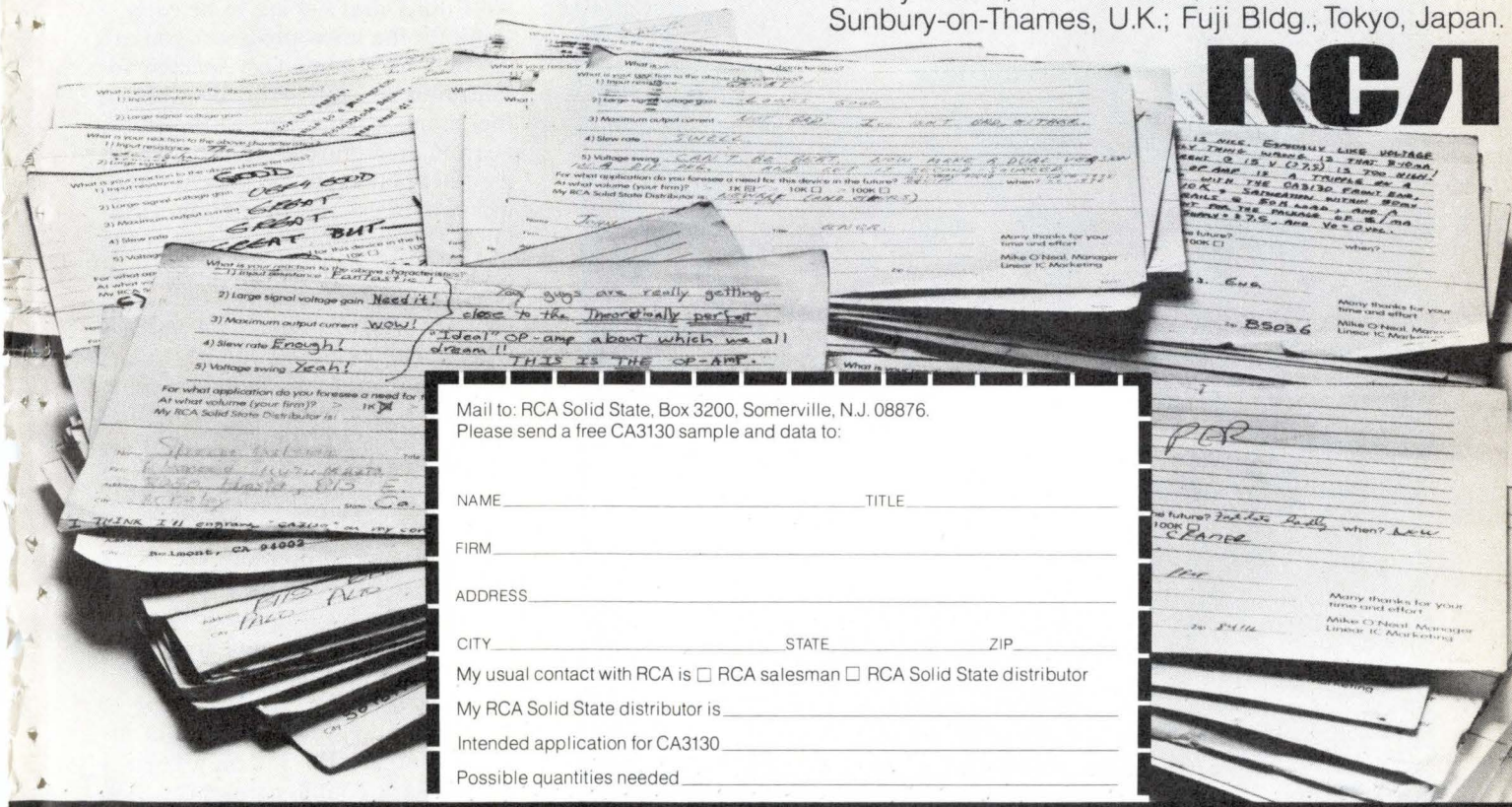
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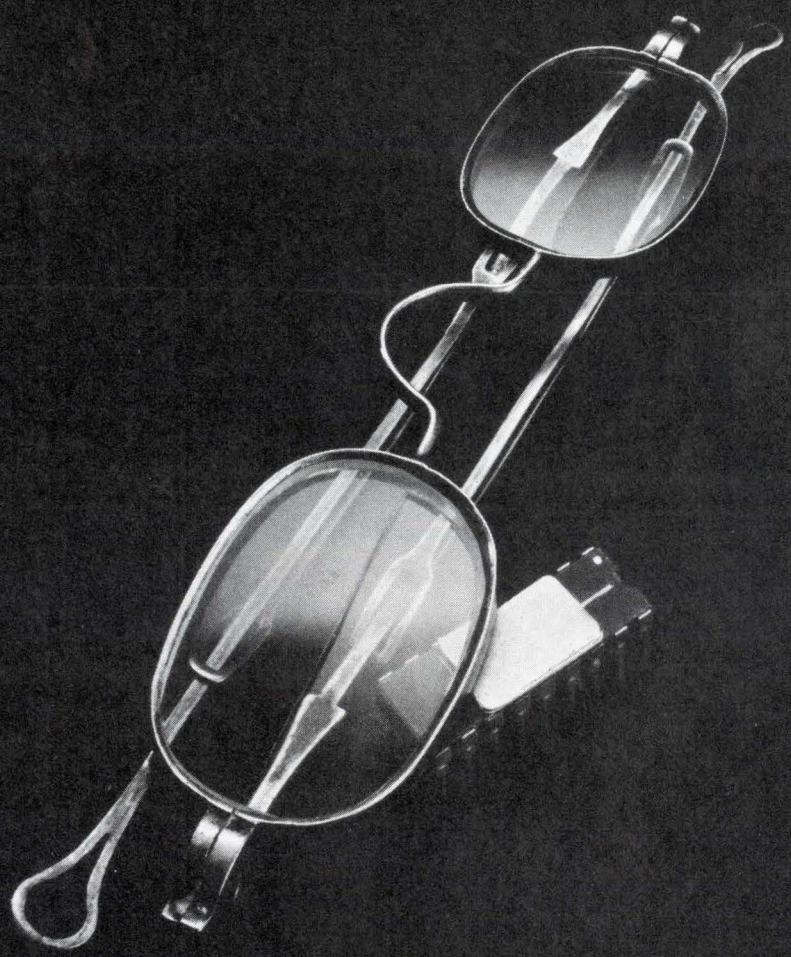
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tablished. The failure rates due to the electronics were really extremely low. It was the first high-volume semiconductor item used in the automobile—certainly the first high-volume integrated circuit. I think that was very important.

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Q: Any foreign business?

A: In the U.S. there's a tendency toward custom programs. The foreign automotive manufacturers are much more amenable to buying standard components. We felt that at this distance we couldn't really do an adequate job working on custom programs. So any deals we have with the overseas people have been on standard products.

Q: Do you see a microprocessor in the auto by 1977 or 1978?

A: I think that's going to be early. I think for the microprocessor you are going to need some very specific applications to start with, possibly in fuel management. One of the European manufacturers might move on the fuel-management system using microprocessors in production. Once the microprocessor enters the automobile, all kinds of things can be added to it.

Q: Are you working on microprocessors for autos?

A: We've been unwilling to come up with a custom design, so our discussions have all focused around using the F8. Most of us here didn't want to go the custom route. We think that's the wrong thing to do with the microprocessor. We don't think there's enough volume. So our approach has been to persuade auto firms to use the F8 and piggyback on the other volume.

Q: How successful have you been?

A: Up to now we've got a lot of interest. But the F8 has only been a reality for a couple of months. Ask me that again in June or July. □

What's new in solid state...

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Our CA3130 gets many of its winning ways from four very capable relatives. Four RCA op amps that can fill special requirements you may have. If you need programmable linear gain control, check the CA3080. For high crossover frequency plus high slew rate, there's the CA3100T. For high output current and easy programmability, the CA3094E. For low power supply drain, the CA3078T.

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Beyond the table, here's more typical data about the CA3130:

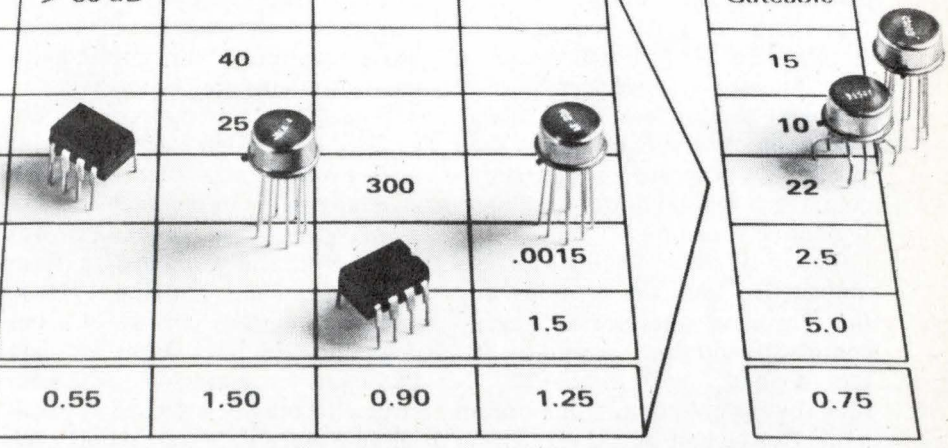
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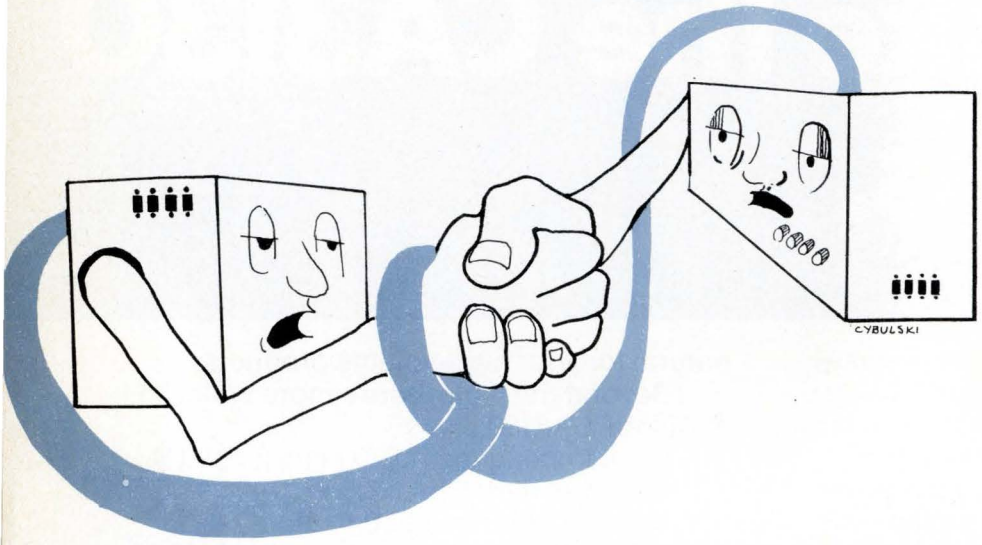
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Slew Rate, V/μsec		25			10
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Circle 69 on reader service card



Instruments

Interface bus has kinks

Speed limitation, cost of incorporating proposed standard questioned, but most instrument makers plan to use it

by Andy Santoni, Instrumentation Editor

The instrument interface bus being advocated as an international standard is receiving the backing of some instrumentation makers—witness the display of bus-compatible instruments and instrument systems that occupied nearly half of Hewlett-Packard Co.'s booth space at IEEE Intercon last week. While instrument makers feel it has enough advantages to justify using it in their products, however, some shortcomings in the standard are still giving reason for pause.

There is some feeling, for example, that both the meaning and the format of interface messages—commands and data—should be better defined, and that the 1-megabyte-per-second maximum data rate may not be fast enough for many applications. In addition, while widespread acceptance of the standard could substantially reduce the cost of assembling instrument systems by eliminating the cost of adding interface hardware at the system level and cutting the cost of software, some suppliers are concerned that the expense of adding bus-compatible circuitry to individual instruments may be too high.

What it is. Based on a concept developed by Hewlett-Packard, the interface has been adopted as an IEEE standard and is in the final stages of approval as an International Electrotechnical Commission standard [*Electronics*, March 6, 1975, p. 10]. The interface consists of a bus containing 16 lines—eight for data and eight for controls—to which instruments may be attached in parallel. In a given data transaction, each device assumes one of three roles: listener, talker, or controller. Bus specifications are written in terms of interface functions (as distinct from instrument functions), messages to and from the interface functions, and state diagrams that serve to describe the behavior of each of these functions.

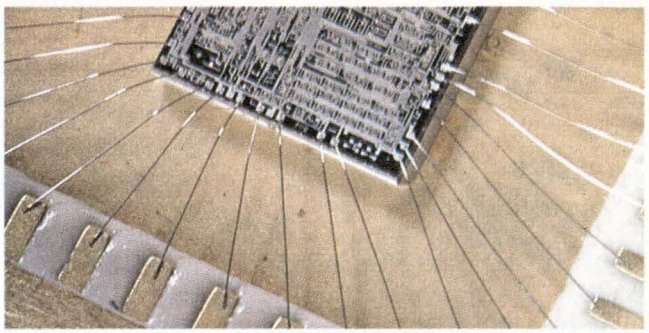
To guarantee that instruments produced by different manufacturers will be able to communicate with each other, the design of the interface circuitry in each instrument, regardless of manufacturer, must meet the requirements of the standard.

The standard interface is most useful in assembling small instrumentation systems with calculator or minicomputer controls, where the cost of designing interface hardware and software could be exorbitant. But choosing bus-compatible instruments just because they might someday be used in a system could be expensive.

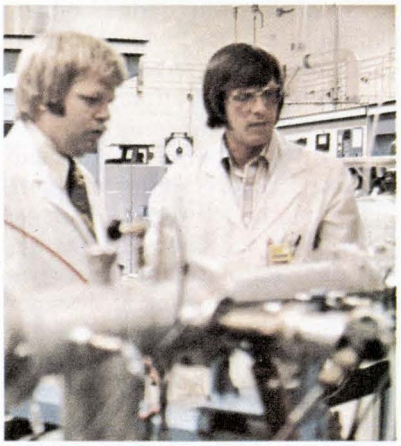
Cost bite. Including a bus-compatible interface on an instrument could increase its price by $250 to $300 compared with a similar product with a simpler binary-coded-decimal output, says Fred Katzmann, president of Ballantine Laboratories Inc., Boonton, N.J. John Fluke Jr., technical director of John Fluke Mfg. Co.'s automatic test systems group, agrees that the bus concept may be too expensive for some instruments, at least until it can be implemented with medium-scale integrated circuits designed for the purpose.

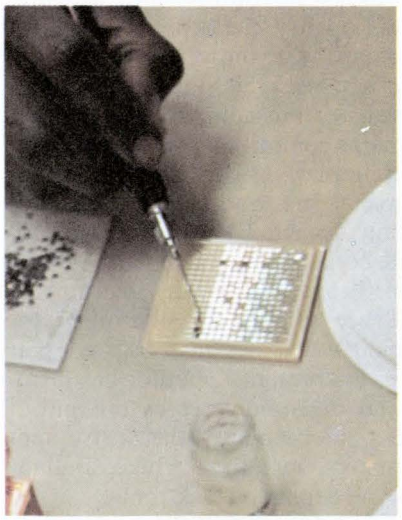
And more disturbing, says Fluke, is the standard's lack of definitions for the order in which data should be sent. The standard does not spell out whether data should be transmitted with the most or the least significant digit first, he notes. The user must ferret out such information from an instrument's data sheets for each instrument in a system and make some provision in software for a digital voltmeter that transmits one way and a counter that transmits another, for example.

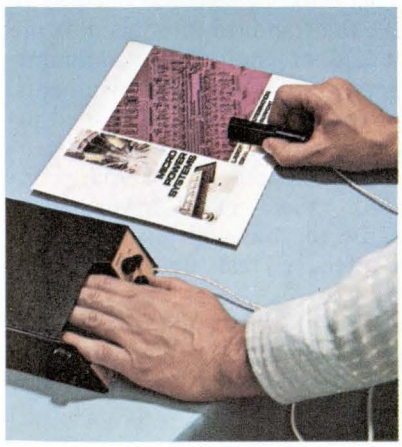
Tektronix Inc., Beaverton, Ore., has had to face up to the same problem, says William Walker, group vice president for engineering. "There are still a lot of things not spelled out or agreed upon in the standard," he observes, and "it does



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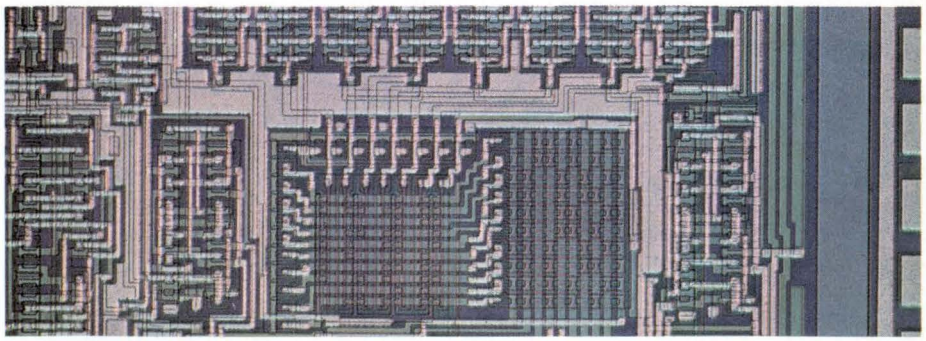
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have some limitations in terms of speed, too."

But Austin T. Kelly, digital operations manager at Weston Instruments Inc., Newark, N.J., thinks the available speed is more than adequate for most instrumentation systems, and conventions will be established to cover other shortcomings. For example, while many command codes—such as "clear"—are left undefined in the standard, Weston has standardized on what a particular command code means to a particular product line—such as digital voltmeters. While a similar command may have a different meaning in another product—such as a counter—customers will be spared at least some confusion.

Don Loughry, corporate interface engineer at H-P in Palo Alto, Calif., explains that not all commands can be standardized across all product lines because of the limited space set aside for such messages. There are only 256 unique codes possible in the assigned 8-bit space, he says, and assigning a standard code for every possible command for every instrument type would require considerably more than 256 codes—and 50% more signal lines than are available.

Each command listed in the standard is not precisely defined either, because the standard was conceived as affecting only interface functions, not instrument operation. Loughry says that if the meaning of each command were completely defined, for example, every voltmeter made by every manufacturer would have to incorporate the same features. Instead, the standard requires two things: first, the instrument designer must define what the device does for each code, then the system designer has to pay attention to instrument-dependent conditions.

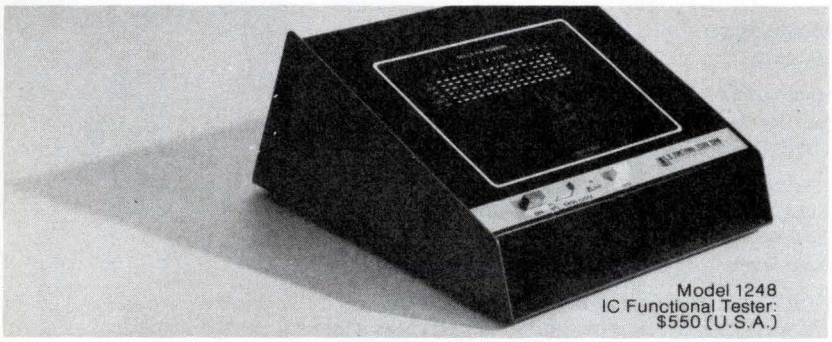
Taking all of this into account, says Loughry, the benefits of the bus standard far outweigh the drawbacks. H-P, which has introduced dozens of bus-compatible products, remains committed to it.

Believers. Other firms, such as Wavetek Inc., San Diego, Calif., and Dana Exact Electronics Inc. of Hillsboro, Ore., have also introduced bus-compatible instruments and are at least considering it for some future designs. Bus-compatible instruments should be introduced—in some cases by the end of this year—by many other instrument suppliers, including Fluke, Ballantine, Weston, and Tektronix.

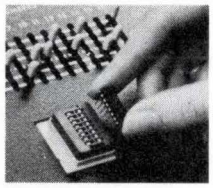
Tektronix, in fact, has decided to make the standard interface bus the "method of choice" for communicating with its digital instruments, says Walker, and has developed internal guidelines to cover the standard's omissions. Walker is convinced this effort worthwhile because the bus will result in more cost-effective test and measuring packages.

All instrument manufacturers, says Weston's Kelly, "will have to have it in mind or in fact in all new designs." □

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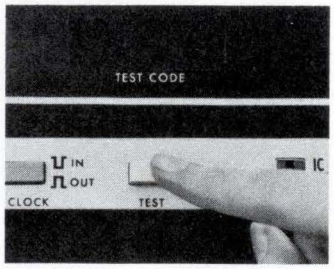
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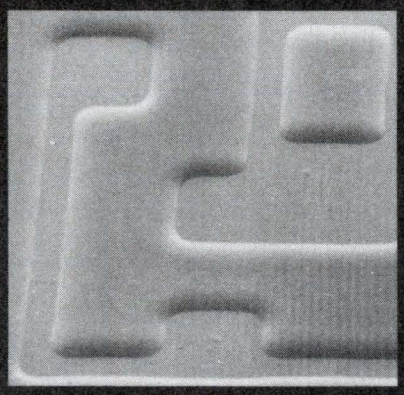


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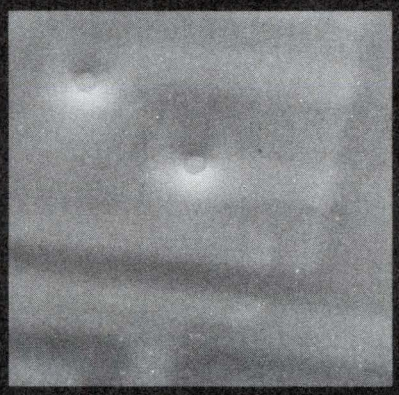
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Here's proof that AZ positive photoresist gives better device yields than negative photoresist.

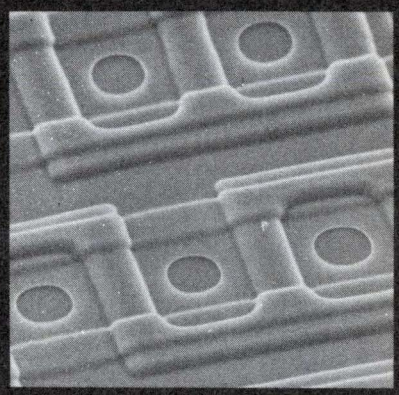
Shown here is a series of SEM's illustrating the unlimited capabilities of our AZ Positive Photoresist Systems. We want you to see for yourself the excellent resolution, edge acuity, and line width control our photoresists provide in both thick and thin coatings. AZ Systems excel in: contact, proximity and projection exposure; aqueous development and removal; wide processing latitudes; accurate reproducibility of photomask geometries in coatings 0.3 to 2.5 microns thick. All of these factors combine to give you increased yields and profitability. Shipley Company Inc., Newton, MA



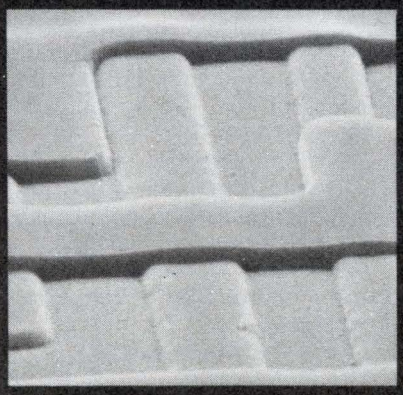
AZ-111 0.8 microns thick on silicon dioxide provides excellent edge acuity, etch resistance and line width control.



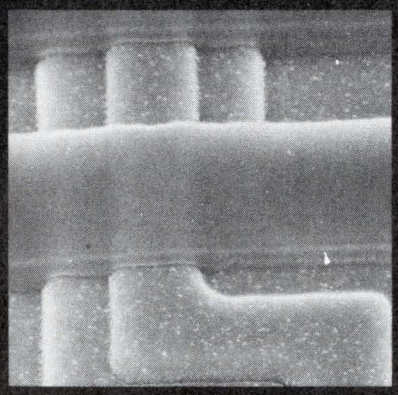
Contact layer coated with 1.8 microns of AZ-1350J is covering 1.5 micron steps. Thick coatings help eliminate pinholes and step breakdown.



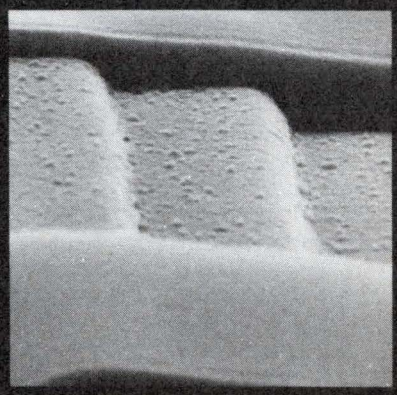
Contacts after etching and resist removal. Note absence of pinholing and sharp edge acuity.



AZ-1350J on aluminum showing excellent step protection through the use of thick coatings.



AZ-1350J on aluminum gives excellent edge acuity despite wide thickness variations.

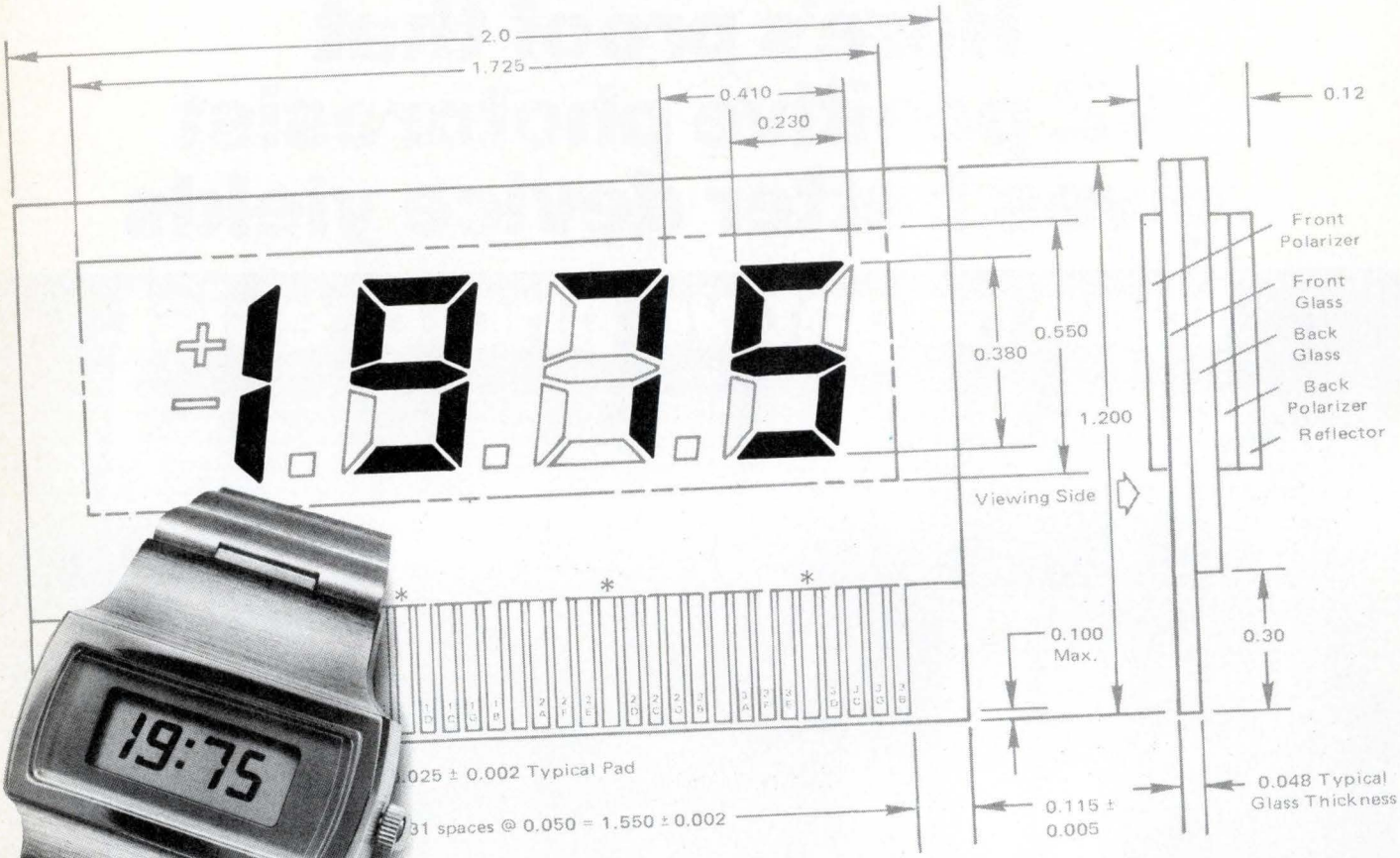


AZ-1350J allows "0" pinholing during etching.

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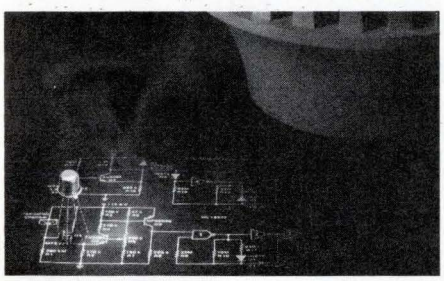
MC6860 is TTL compatible and operates from a +5V power supply. The space saving 24-pin device sells for only $30.00 at 100-999 quantity. Device data and application note AN731 are available.

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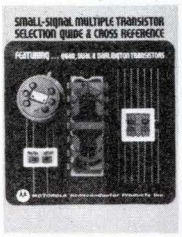
In addition to the regular monthly courses in Phoenix and those already scheduled elsewhere, groups of 15 or more can arrange sessions for other times and places. Here's the May schedule:

Philadelphia, PA	May 6, 7 and 8
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Companies

Will success spoil AEI?

British semiconductor maker finds business booming in power, microwave devices, worries about too much growth too soon

by William F. Arnold, London bureau manager

Many semiconductor makers are brooding about the economic downturn, but AEI Semiconductors has a different worry—how to cope with rising sales. The British company makes microwave and power semiconductors, which have been enjoying a boom. AEI, which more than doubled its sales during the last two years, predicts 10% growth this year after discounting inflation.

Triggering AEI's good fortunes is a surging world demand for power semiconductors for electrification of mass transit and railways. This market could reach $50 million a year if all the planned projects come to fruition, estimates A.J. Sadler, AEI's managing director. Possibly equaling that market is another generated by electrification plans as a number of countries enlarge their power grids to cope with the oil crisis, he adds. Much of this expansion entails high-voltage, direct-current transmission, now that power thyristors are as effective as vacuum tubes.

The company's microwave business, although smaller, also looks good because of demand in radar and communications gear for such devices as mixers and detectors.

Of course, AEI doesn't fish alone in these waters. Microwave-component competitors include Thomson-CSF in France, Mullard and Plessey in Great Britain; and Microwave Associates Inc., Hewlett-Packard Co., and Alpha Industries Inc., which took over Sylvania's microwave-semiconductor business, in the U.S. On the power side, it jousts with Westinghouse Electric in the U.S., Brown-Boveri & Cie. in Switzerland, Sweden's ASEA, and AEG-Telefunken and Siemens in Germany.

AEI has a reasonable 4:1 balance between power and microwave sales. About 10% of its income is from research contracts, and these, says the company, enable it to remain in the forefront technologically. At the same time, AEI, seeking a rise in export sales above its present 25%, sells into a domestic market of about $25 million in power semiconductors alone.

Problems. What's AEI's problem? Perhaps the company has grown too much, too soon. At about $12 million in annual sales, the company is small enough to suffer strain with any expansion. In a classic management problem, AEI must call its shots carefully to enjoy the optimum growth with the right products. The latter is especially vexing, executives say, because the company might profitably increase sales across its range of devices. But AEI isn't large enough to do that, so it must pick and choose.

Even physical expansion must be carefully considered. Located in mostly rural Lincolnshire near the middle Eastern coast of England, the company has profited from an easy informality among employees. Executives are concerned that a new factory wing now being built might change the feel of things because it will increase production about 50%.

To manage what appears to be a lovely problem, Sadler says, "we've rationalized the commercial structure by appointing a commercial manager." Under the new setup

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ec = eb = 30Vp-p
ic = 3.6mAp-p
ib = 2.8mAp-p



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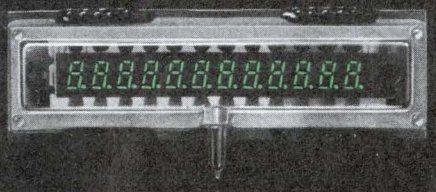
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ec = eb = 24Vp-p
ic = 3.5mAp-p
ib = 2.5mAp-p



Wd. 100mm
Lg. 40mm
Segment 9.5mm

FG-125A2
ec = eb = 24Vp-p
ic = 2.0mAp-p
ib = 2.0mAp-p



Wd. 75mm
Lg. 26mm
Segment 5mm

Our pint-size pigmies

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Wd. 65mm
Lg. 24mm
Segment 5mm

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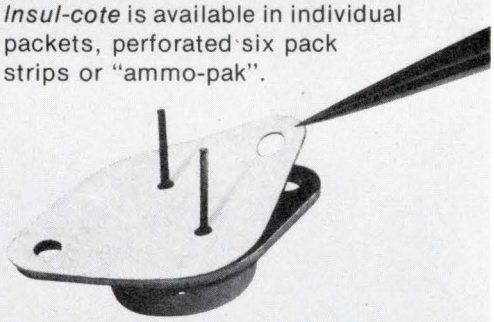
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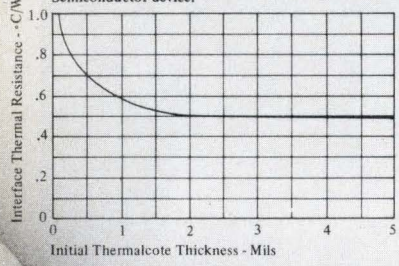
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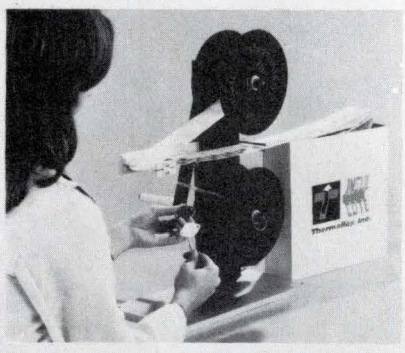


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Probing the news

Sadler's new number two man will oversee and coordinate thrusts by the power and microwave sides, which heretofore operated a little more autonomously. Under him are executives for home markets, export sales, advertising, and exhibits.

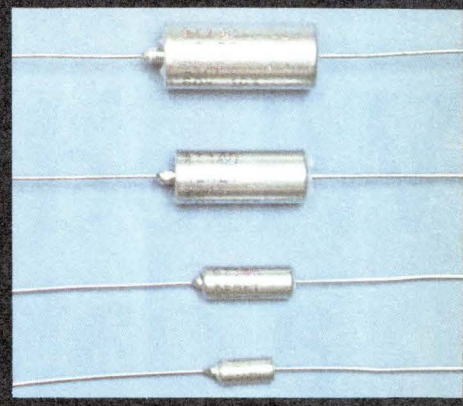
To concentrate on technology, AEI brought in its own man, David Crees, from the Hirst Research Center of the parent company, General Electric, which has no connection with the U.S. namesake. His charter is to beef up the engineering staff.

Engineering accent. Importantly, the company is concentrating its efforts on products with "an accent on items of high engineering content," Sadler says. More sophisticated high-power microwave devices will be featured, but we're retaining an effort on smaller products," he adds, such as bread-and-butter small zener diodes and thyristors. Successful old procedures aren't forsaken, however. Retained, Sadler says, is the proven philosophy of having the "business broken down into five or six small groups which are run as independent small businesses within the company." He notes that "with our mix of products, that's almost inevitable."

For power markets, "anything to do with energy conservation looks good," says William W. Reid, the new commercial manager. Besides diodes and power hybrid devices, he pinpoints such good markets as 2-inch thyristors up to 2,000 volts and 5- to 10-kilohertz choppers for mass transit. Looking good on the microwave side, too, says John R. Lohoar, microwave marketing manager, are Gunn oscillators for line-of-sight communications; mixers, which are the heart of radar receivers; and doppler modules for traffic-light, police radar, and industrial use.

Microwave devices in shipboard satellite terminals for upcoming U.S. and European satellite communications systems appear to be emerging as a key market. Marconi, a sister firm within General Electric Co., makes such systems [*Electronics*, June 13, 1974, p. 65]. Targeted, too, are devices for automatic train-control systems. □

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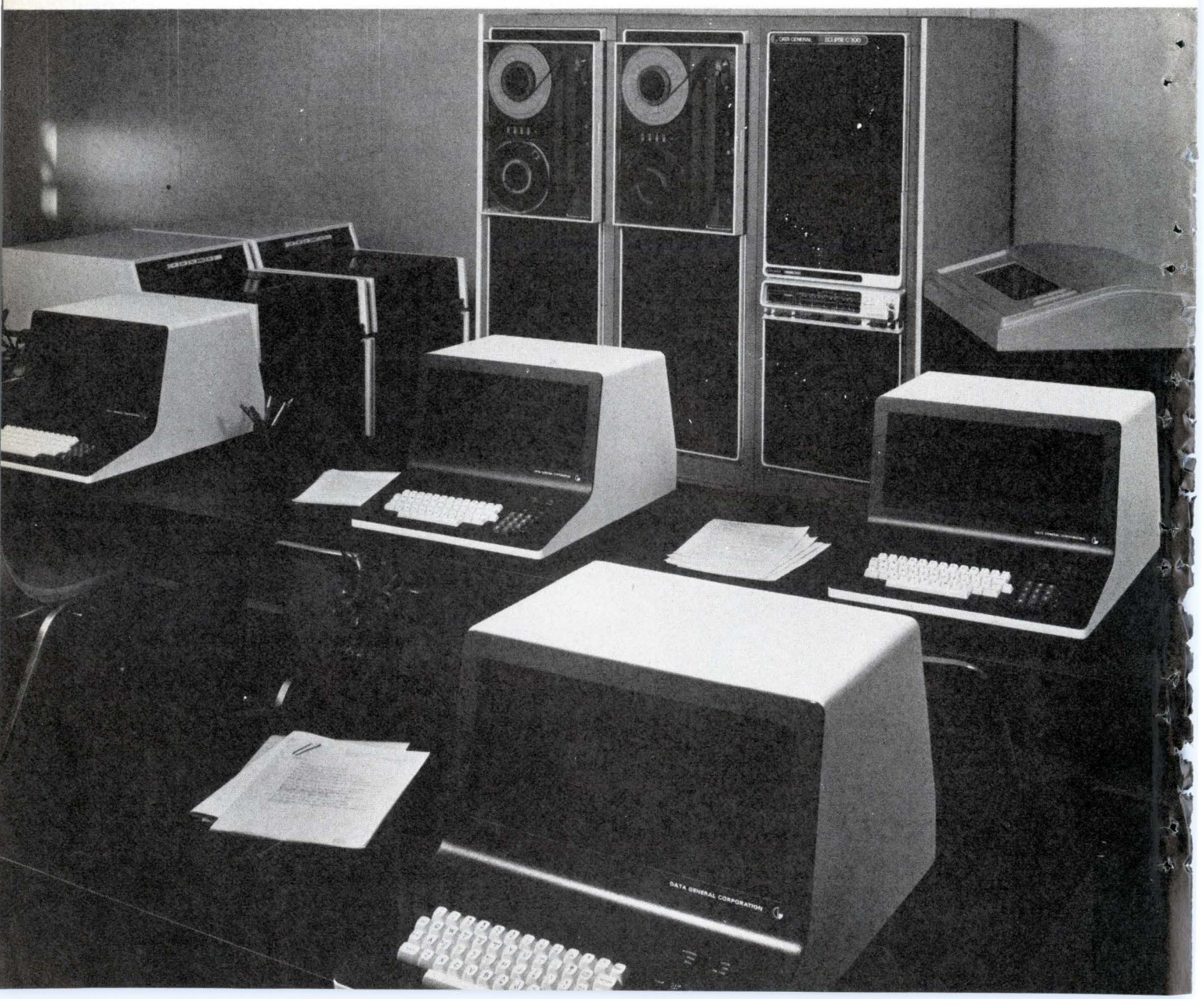
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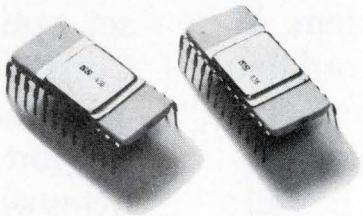
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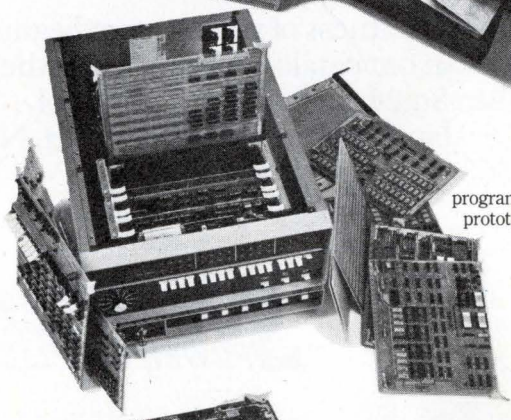
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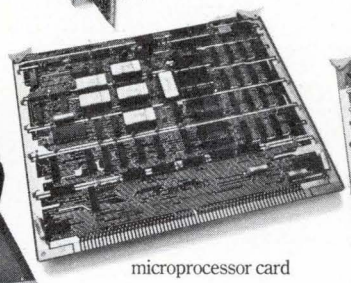




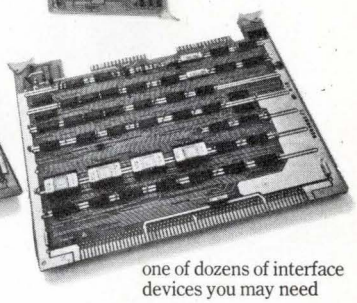
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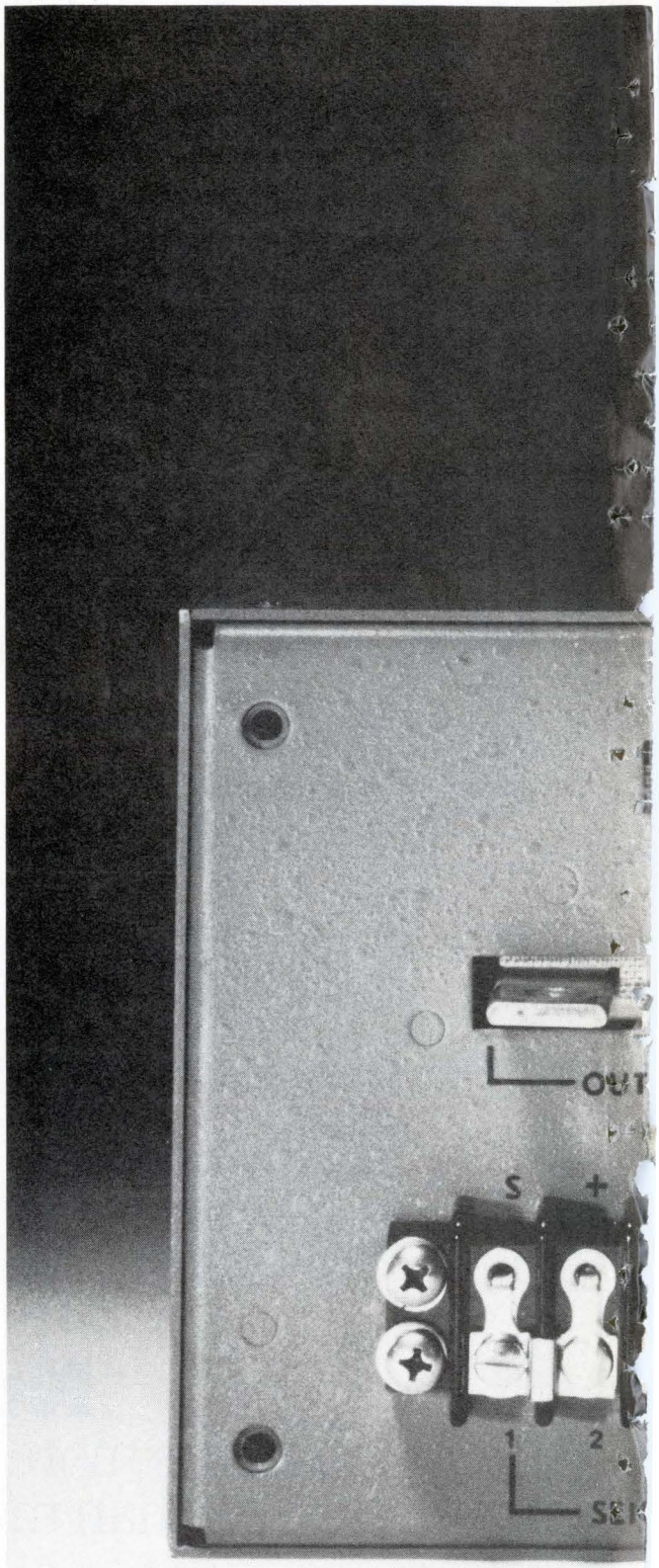
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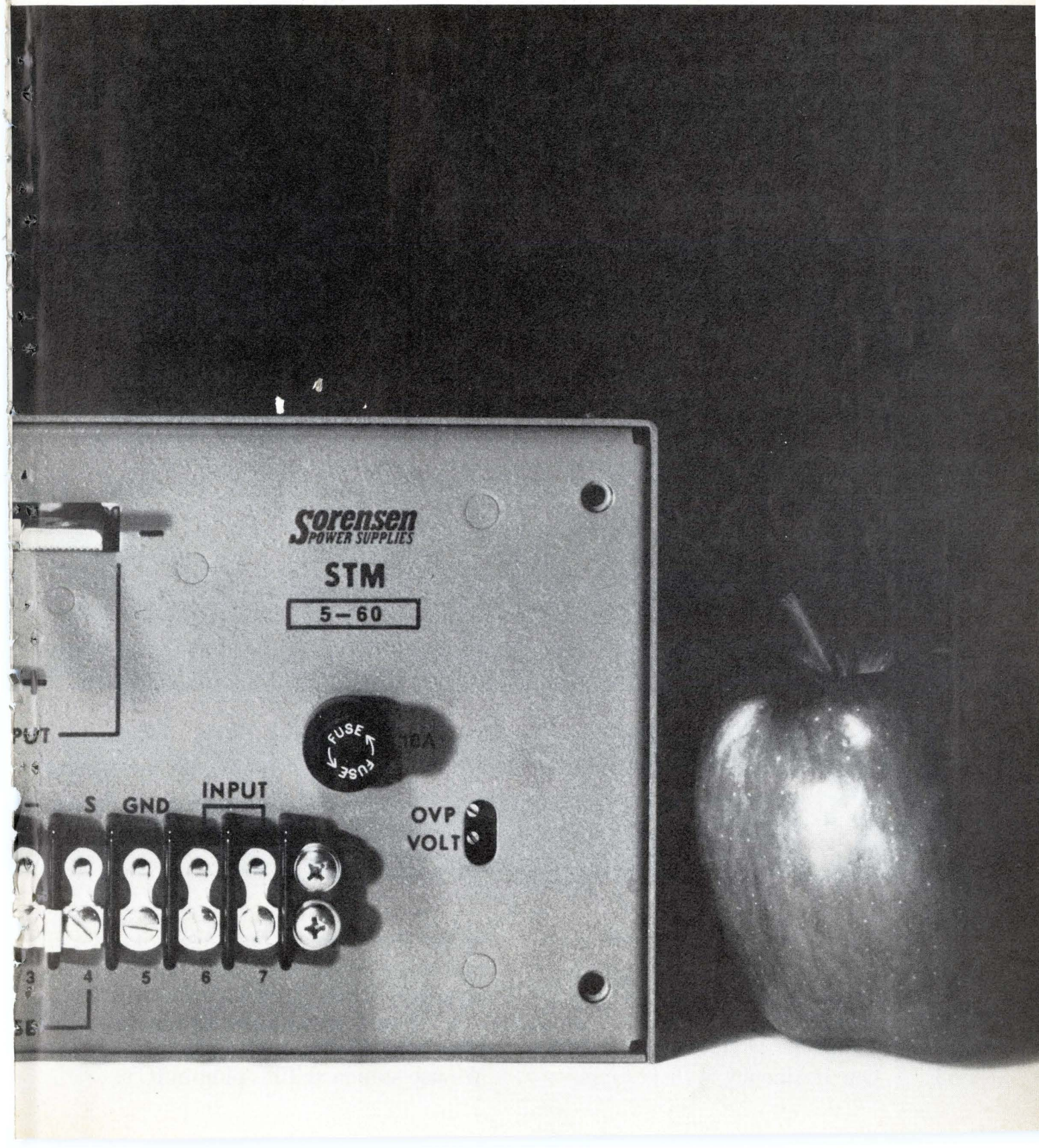
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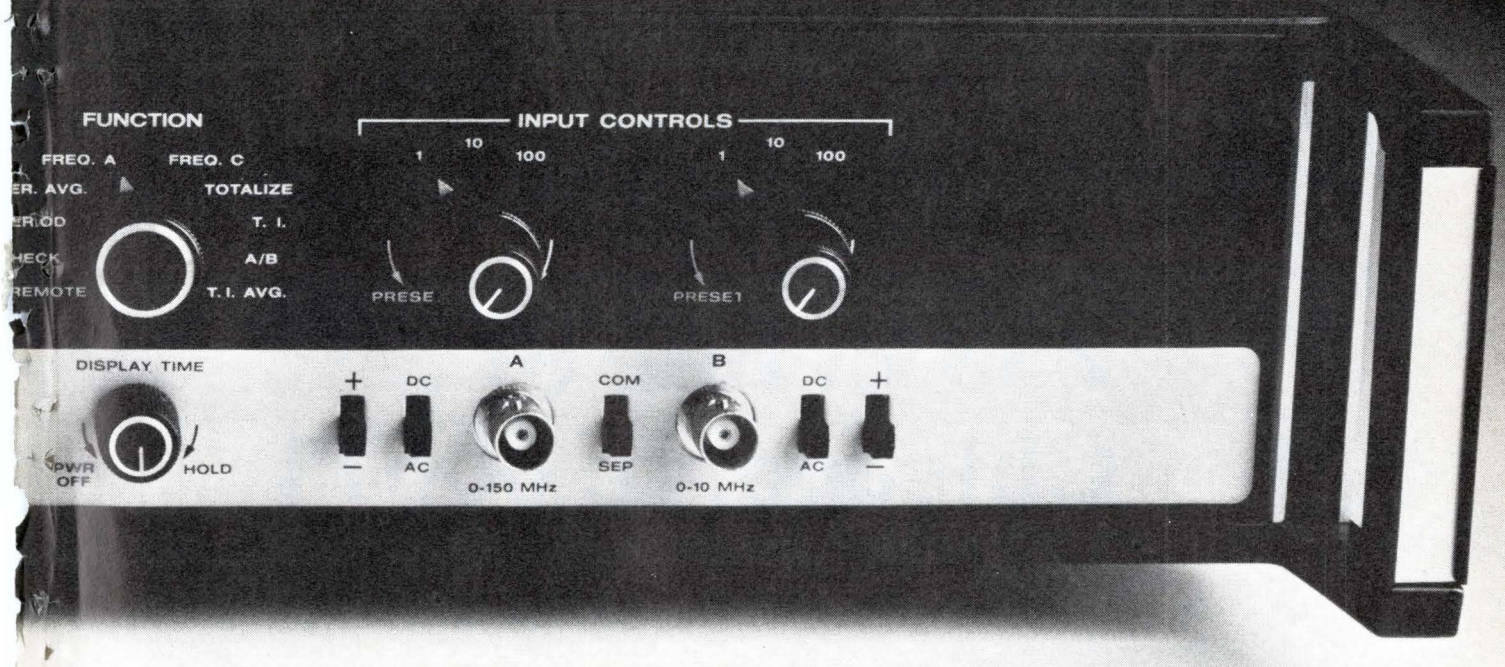
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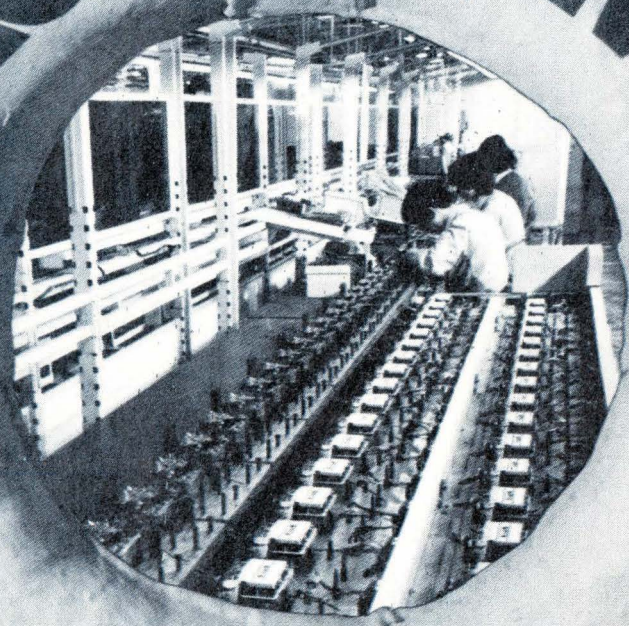
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PRODUCTIVITY



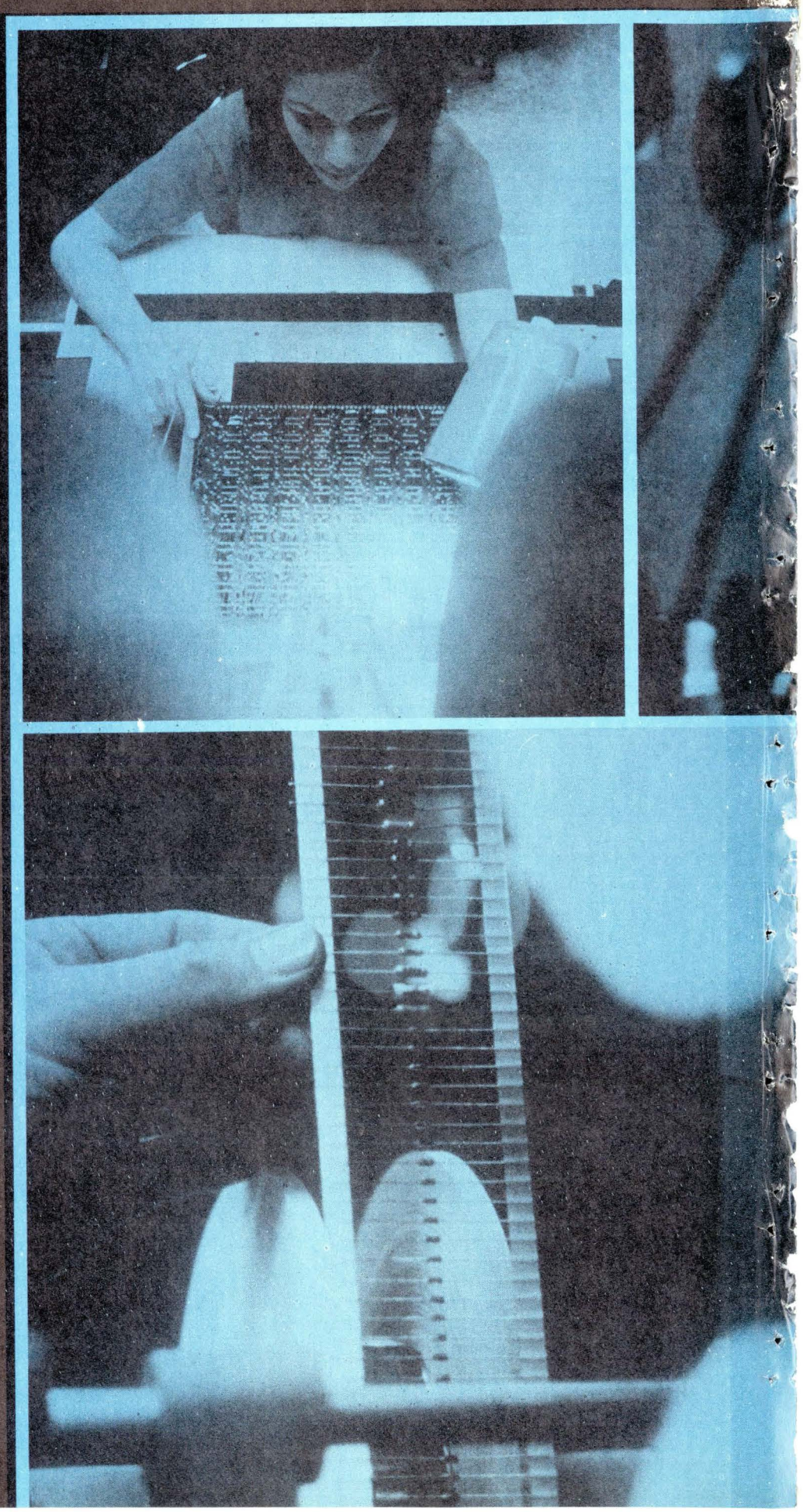
A SPECIAL REPORT

It's no secret that this year electronics companies have lost the magic that seemed to promise boundless growth. Despite a broad market base, the recession has treated many electronics firms as harshly as other hard-hit industries.

Plagued by lack of cash, rampant inflation, rising costs of labor and materials, executives have adopted the harsh measures required in difficult times. They've tried to cut losses and remain profitable—through reductions in staff (severe in many cases), delay in ordering capital equipment, cuts in R&D budgets, and longer work hours.

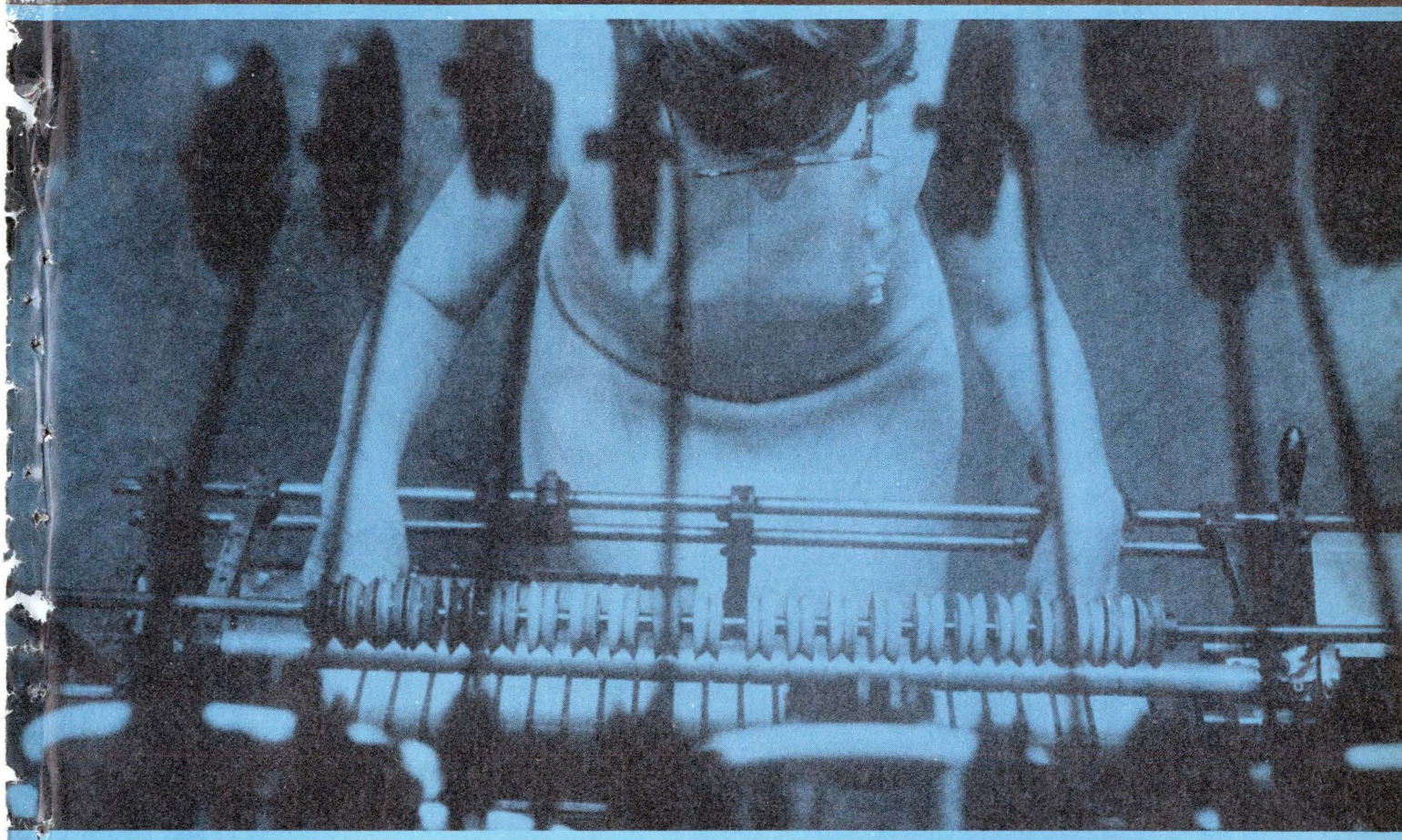
Most of these are short-term measures. As the crunch disappears, so will many of these actions. But many companies are taking advan-

Eliminating manual handling of components is a basic aim of productivity planning. At right, component insertion at General Automation; below, tape holding assorted axial-lead components for insertion by programable machine which can bend leads at varying distances from a component's midpoint, also at General Automation; far right, automatic yoke-coil winding operation at Zenith.



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Government 139



tage of the current lack of pressure to get products out the door for more thoughtful planning. These companies are turning attention to improving productivity.

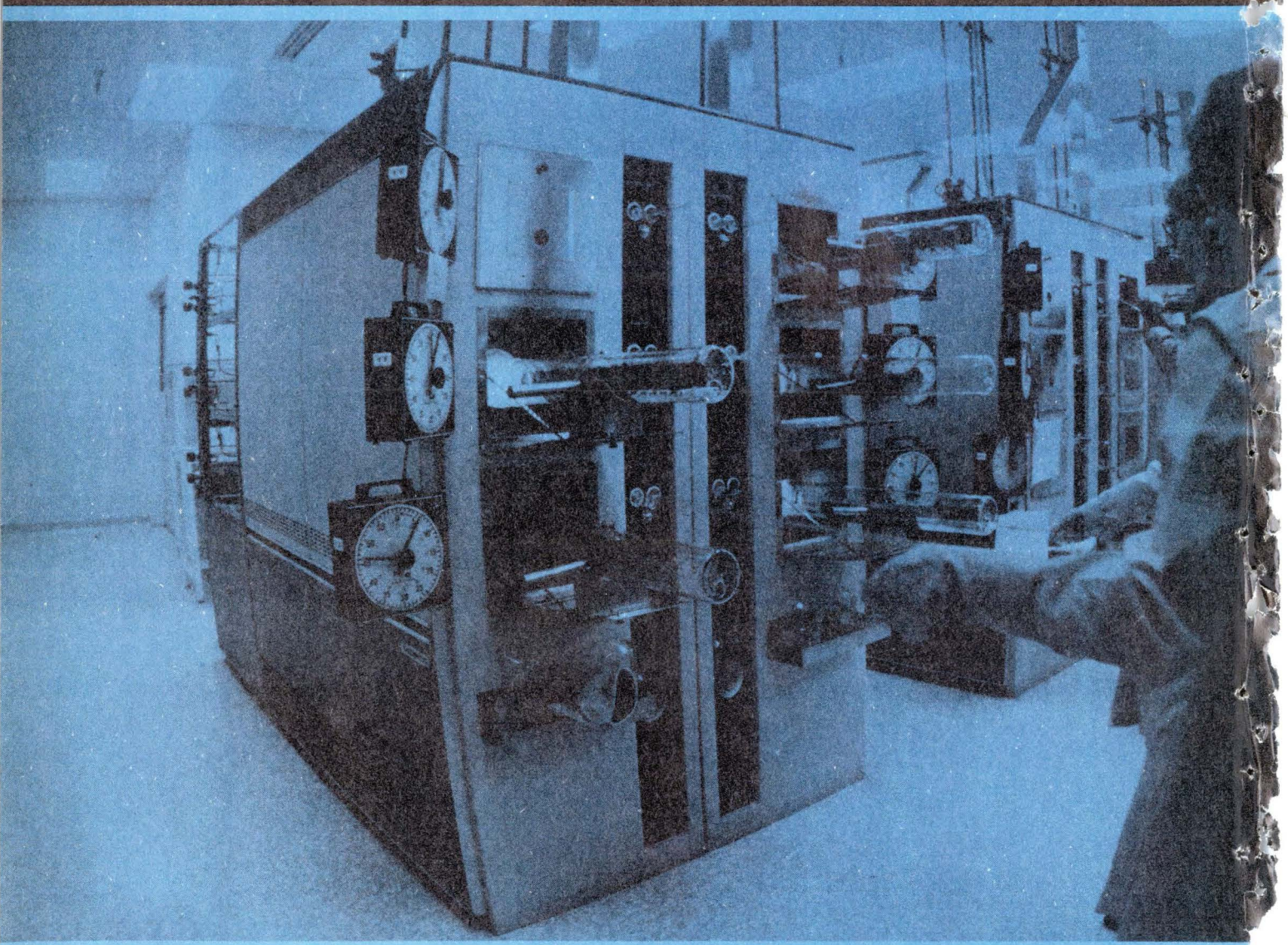
Attention to productivity isn't new to well-run companies. For instance, Texas Instruments, recognized as one of the best-managed firms in the U.S., has consistently made productivity the center of its operations. Last year the firm noted that for five straight years (1968–1973) its productivity per employee had increased by almost 15% each year, allowing TI to reduce prices by an average of 8% a year. This is impressive when considered against the average of a 4.4% increase in prices for the rest of the private sector during the same period. Another enlightened firm, Hewlett-Packard, has been innovative in increasing productivity by introducing such new concepts as flexible work hours.

Other firms are working hard at productivity improvement. Key managers and management consultants interviewed by *Electronics* editors

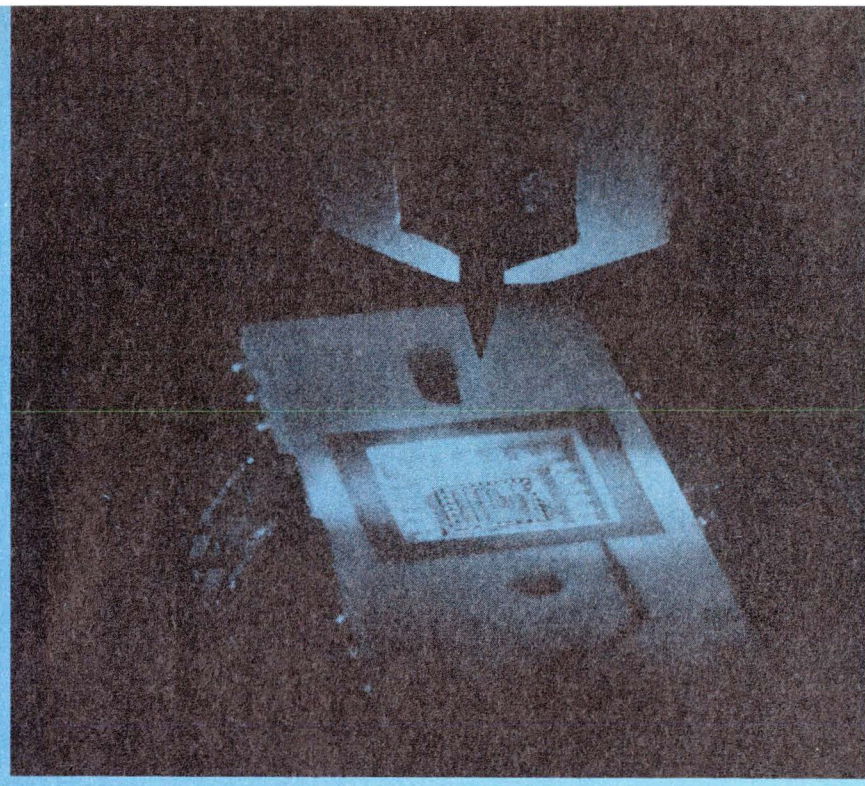
stress that those companies that continue to improve their product and boost productivity at the same time are the companies that will emerge from the recession on top.

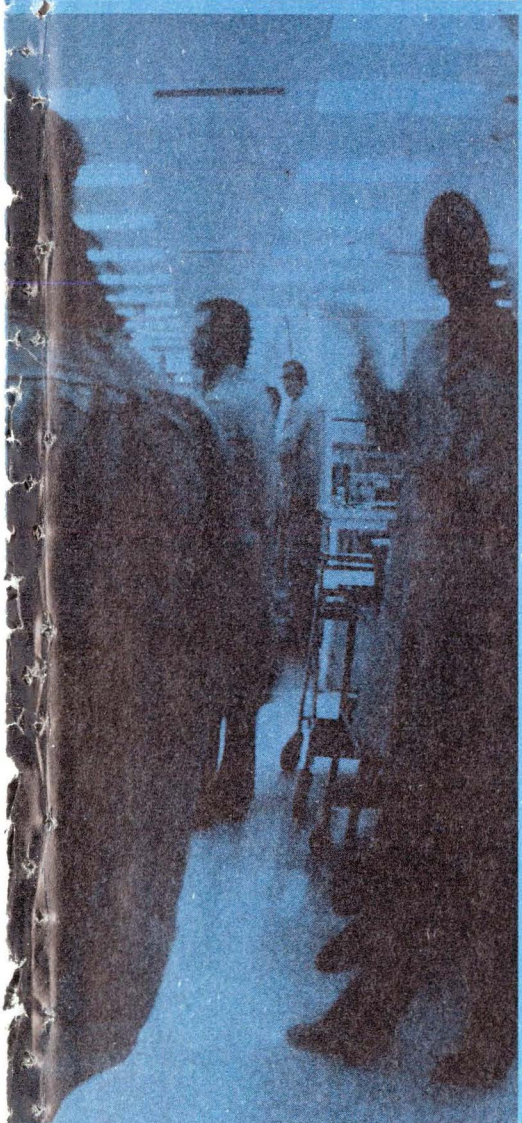
Although it has many definitions, productivity is basically a measure of product output per employee – in many ways similar to the engineering definition of efficiency, the ratio of output to input. In simple terms, if industry wants to stay profitable in the face of mounting labor and materials costs, it must find a way of turning out more products at less cost, either by improving existing resources or by providing additional resources.

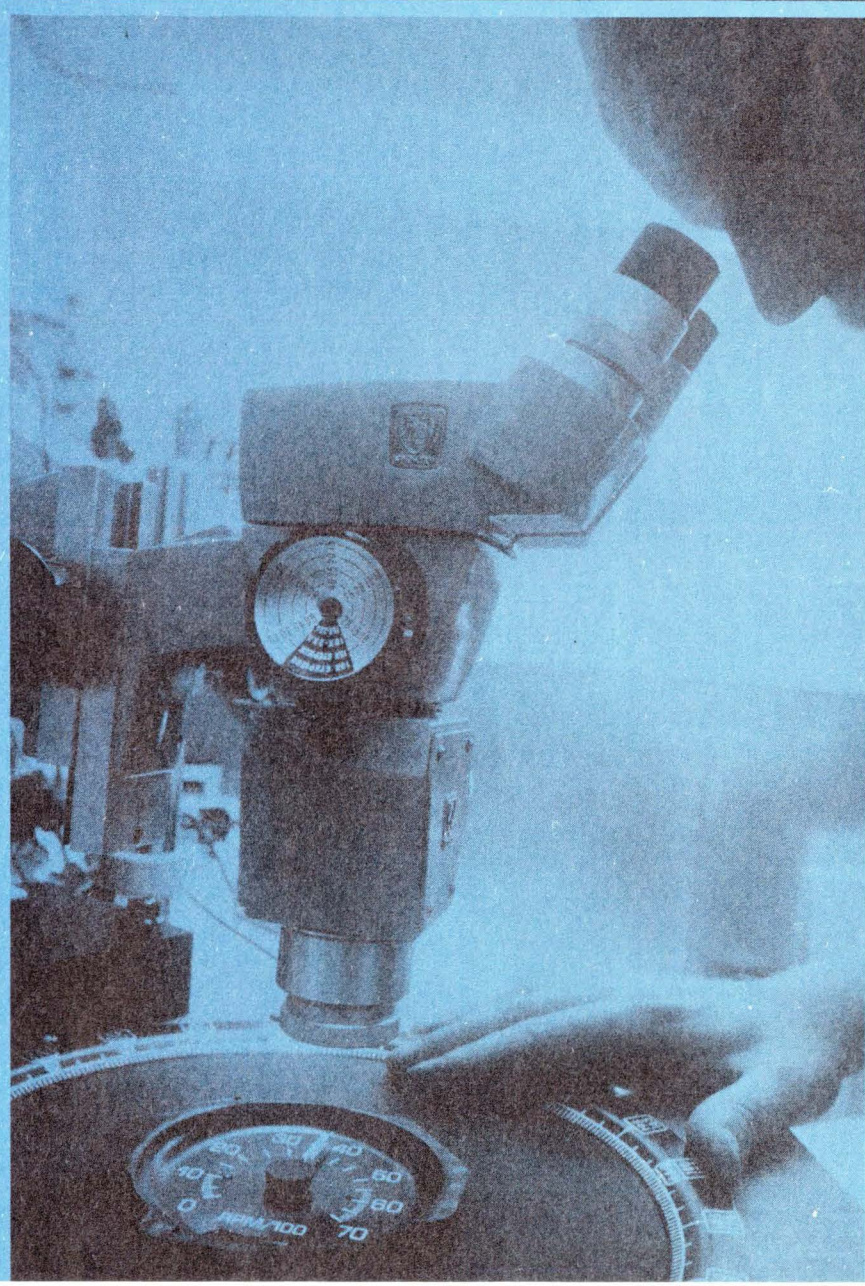
How can companies increase productivity? There are several ways. First and most obvious is automation. Second, companies can improve productivity by better training programs, and by motivating their employees through various incentives—not only the concrete incentive of monetary reward, but also through employee participation in some of the important decisions leading to product design and manufacture. Here the en-



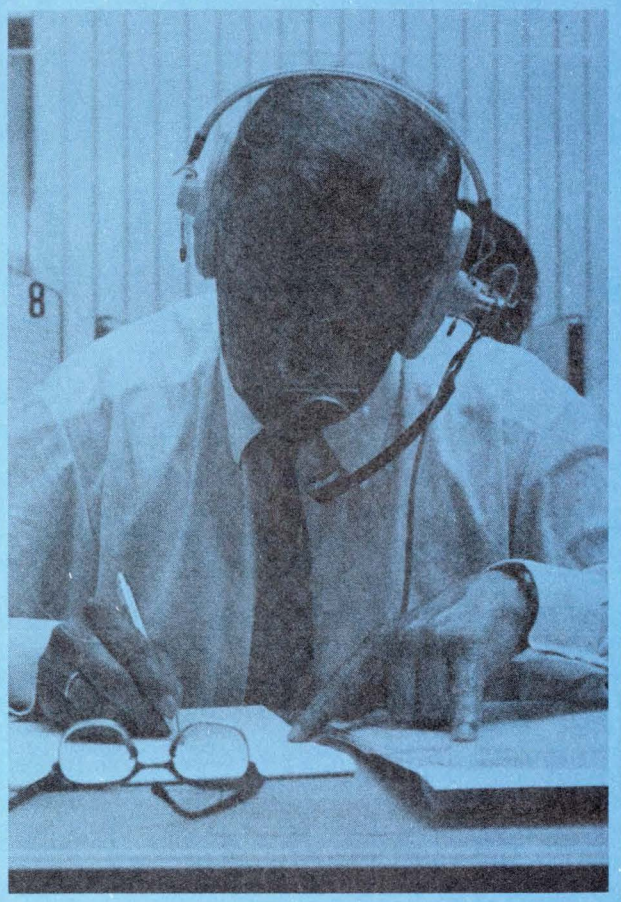
Semiconductor firms use variety of methods to increase yield and hence productivity. Left below, diffusion furnaces for 3-inch silicon wafers at National Semiconductor; right, automatic wire bonding and, below, wire bonds being stressed on centrifugal tester, also at National.











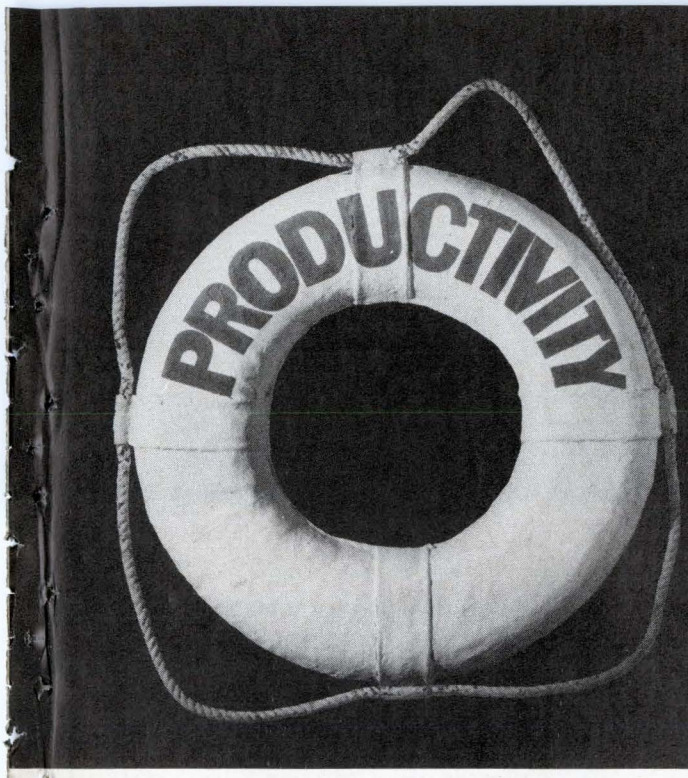


Involvement of people in productivity means training and motivation at all levels. Above, Siemens managers learn from TV display and, left, receive language instruction in audio lab; below, employees' soccer team sponsored by Hewlett-Packard.

gineer plays a vital role. Not only does he produce new technology that can make new products cheaper to build, but his know-how can be brought to bear on improving the manufacturability of existing products.

It's true that electronics has long been associated with innovation, spending more than any other industrial sector on research and development, but now R&D is declining after holding even for five years.

Thus, to resume the growth that has been the hallmark of electronics, the industries have their work cut out for them. In the following pages we look at what electronics companies are doing or plan to do about increasing productivity. It could mean the difference between sinking or swimming in the rough seas ahead.



How automation pays off

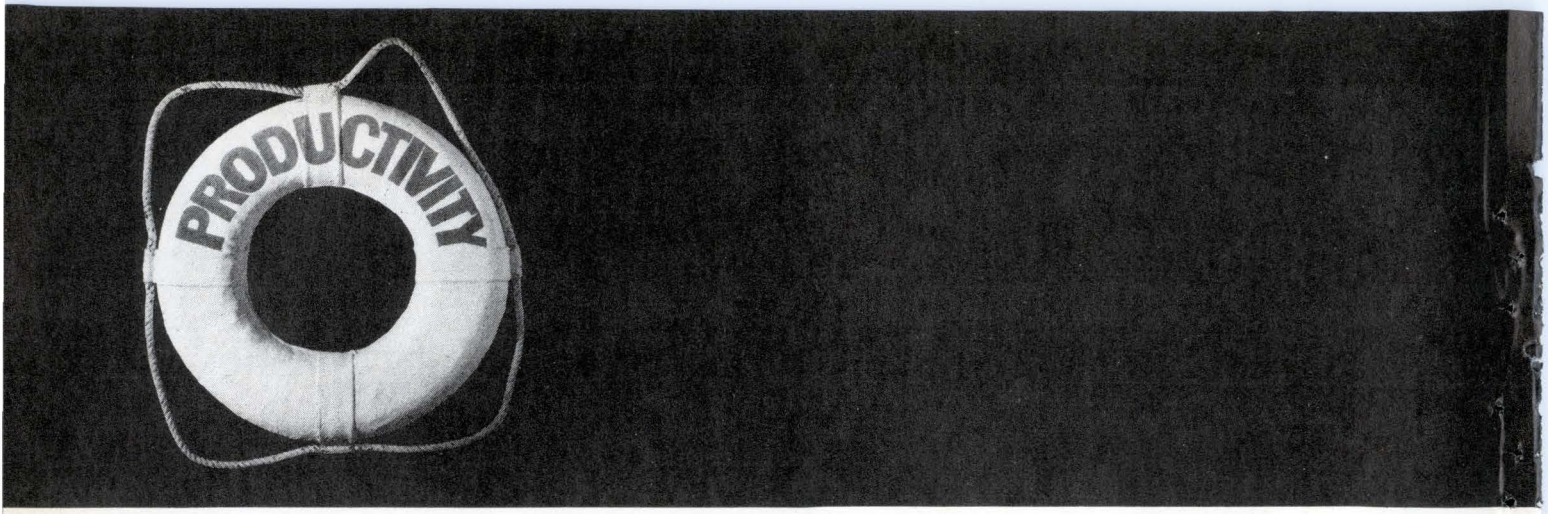
Automation is helping electronic component and equipment manufacturers boost productivity to cope with rising costs and to prepare to ride crest of new sales when upturn comes

☐ The time when electronics companies could afford to make their products with little attention to automation is gone. The question is not whether to automate, but how, and the most foresighted electronics companies have been mechanizing their operations steadily for years, increasing their productivity. These are the companies that stand the best chance of being out front when the recession has passed. As the chief operating officer at Texas Instruments, J. Fred Bucy, puts it: "The people that have done the best job of mechanizing, continuing cost reduction, and improving yield are the ones who are going to be able to recover fast. You continue mechanization, and when the upturn comes all you have to do is crank up the machine."

Automation is the one method of boosting productivity that lends itself best to measurable results, as opposed to other factors such as employee motivation and product-design innovations. Its costs, too, while often higher than first estimated, are usually predictable. The most effective applications of automation, however, require long lead times for planning, besides substantial capital investments and good communications with production staffs.

As for the electronics industries, many have commented on a certain irony: electronics has done much to automate other industries while in many cases its own manufacturing techniques have lagged behind. The reason for this, however, may also explain why electronics has been able to contribute so heavily to other industries. The rapidly changing technology of electronics in many cases has inhibited the adoption of the rigid formats that lend themselves to automation.

But in a recessionary-inflationary economy, electron-



ics firms are facing dropping sales and rising labor costs, and are fighting to preserve profits—a fight that comes down to making their operations more efficient. In terms of manufacturing, this means automation.

This could very well be the time for many companies to automate, or, if capital investment funds are tight, at least to plan for automation in order to be among the first to reap the benefits of a business upturn, whenever it comes.

Donald Hawkins says such planning seems to be exactly what is going on now throughout electronics manufacturing—and Hawkins should know. He is marketing manager for USM Corp.'s Dyna/Pert division, Beverley, Mass., one of the few suppliers of automatic component-insertion equipment. Hawkins says many companies do appear to be preparing for an upturn: "Manufacturing specialists are out structuring, evaluating, and getting quotations on machines, assigning dollar-and-cents values to different system configurations." During the business slowdown of the early '70s, he says, "there were a great number of teams from large manufacturing companies and consulting firms traveling around the world studying automated operations. As soon as there was an inkling that the industry was pulling out of the recession, our order rate doubled, tripled, and quadrupled in a month or two." He adds: "We are forecasting that the same thing is going to happen this time."

Most companies have had ongoing programs to automate around serious bottlenecks in hard-pushed operations. As William Hanson, group manufacturing manager at Digital Equipment Corp., Maynard, Mass., says, "Our biggest effort [toward automation] occurred during the boom times." As for the present efforts, Hanson says, "when you have a little time to breathe, you end up doing more planning. People now may have more time to get things in order and lay out a two- or three-year plan with a little more detail and thought."

The big push on productivity in the electronics industries actually began about three years ago, according to Roger Long, a senior staff member at Arthur D. Little, Inc., Cambridge, Mass. But he notes that, "Up until this year, most companies had the capital to back up some automation ideas. Now, at least temporarily, and probably for the next six months, they are going with what automation has already been installed. There is just not the capital now to expand automation."

It's true that to save money, manufacturers must often spend lots of it, and with the uncertainty as to when an upturn might come, many firms have frozen capital spending. "Very often firms can afford it but are simply afraid of the future," says Jeff Waxweiler, marketing vice president of Algorex Data Corp, Syosset, N.Y., "Some of the most profitable firms around are freezing appropriations. Nevertheless, there is a spirit to improve productivity among engineers and engineering management—they do listen to new ideas."

Automated components production: machines for mass outputs

New ideas are being tried throughout the electronics industries. There is, however, a basic difference between the automation approaches in the two basic categories of electronics manufacture: components and equipment. In equipment manufacturing, the job is primarily one of handling and assembly relatively large parts, while components production is often based as much on materials processing as on assembly. Also, because equipment assembly tends to be somewhat similar from company to company, there are commercially available automated machines. But in components production, equipment tends to be one-of-a-kind developed over a long period by the manufacturer himself for his own production lines.

At Allen-Bradley, the Milwaukee-based resistor company, for example, carbon-composition resistor manufacturing has been steadily improved through mechanization for 35 years. Just last year the company was able to squeeze another 8% out of the production lines by adjusting them to run faster. It was not simply a matter of resetting a dial, however. The program was in the works for a couple of years, first with speeds increased on an experimental basis and then extensive tests to see if the increased speed degraded the product.

"We carefully watched yield, and we broke open the resistors for visual microscopic tests of proper fill and dispersion of materials," says Robert Linsley, manager of electronics manufacturing. "We also observed the equipment to make sure it wasn't shaking apart faster. At the final, optimum rate, we found that we do not de-

grade the product at all and we do not run the equipment excessively faster."

Improvements in components manufacture are not usually so simple as turning up the speed. In fact, most improvements come from continual analysis of machine operations, trying to cut its handling losses and reducing breakdowns. These more subtle problems are often the most difficult to cure, since they require constant study. For example, Linsley says that between 8 and 12% productivity gains were made on marking machines for resistors by "nitpicking." To improve the yields, he says, "I sat an engineer on the machines for about a half a year. I can't point out any one thing he did, but all the improvements added together gives us a decent net result of up to 12% productivity gains."

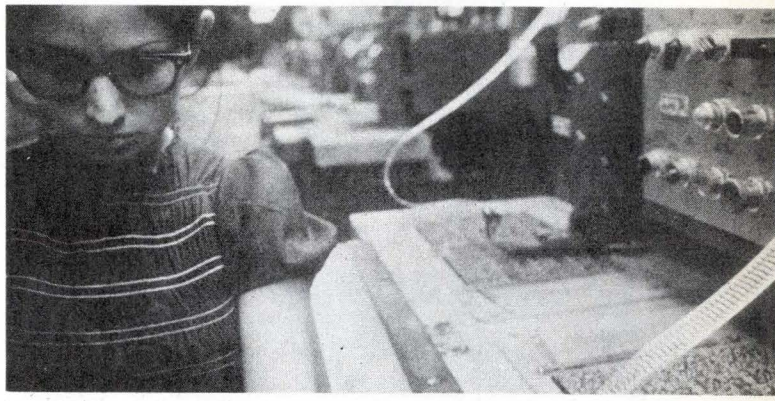
When a company takes a brand new look at a manual or semi-automatic operation, often the automated approach can result in a substantial gain in productivity—provided the company is willing to make the investment in developing the automated machine. Witness, for example, one experience at the Oak Industries Switch division in Crystal Lake, Ill. P. Michael Hassett, vice president, referring to the 100% increase in production speed of a switch used in calculator keyboards, says it's "the fastest thing we've ever done in this company."

The switch was designed from scratch with an eye to automatic assembly. In mid-'72, Hassett recalls, manufacturing began on a semiautomated line that required six operators. A year later, production was moved to the automated system, controlled by solid-state logic, and allowing hands-off manufacturing with a single operator. The semiautomated machine turned out 1,073 switches per hour; the automatic machine (dubbed the "blue line") runs at 2,160 units per hour—twice as fast. The blue line can actually turn out triple the number of switches of the semiautomated line because it can be run on all three shifts. "It's much easier to get one person than six for the graveyard shift," Hassett notes.

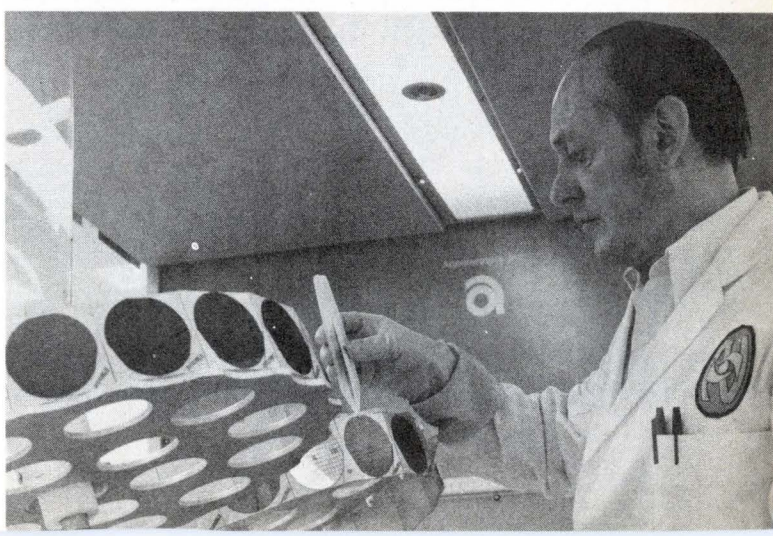
The $200,000 investment plus half a man-year in mechanical engineering, however, could not be profitable without enough present or imminent sales volume to pay for it. And today, many calculator manufacturers



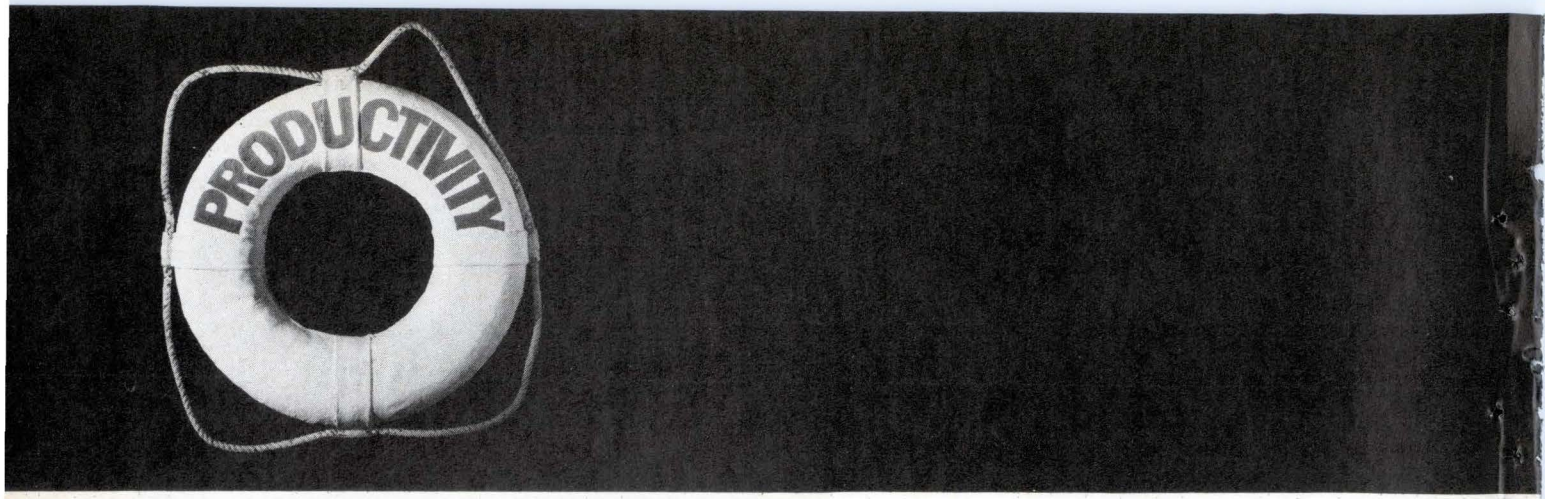
Contact. Machine at Socapex, a French connector manufacturer, inserts 50,000 contacts per day. One operator tends five machines.



Terminals. Zenith Radio Corp. uses 25 Amp Inc. machines, controlled by DEC minicomputers, to insert terminals on pc boards.



High yields. Worker at Motorola Semiconductor (right) loads semiconductor wafers for ion implantation of critical impurity profiles.



have integrated their operations and are buying fewer switches outside. Nevertheless, Hassett says the company feels its investment in automation was sound.

In connector manufacture, there has been a trend toward greater use of stamped contacts automatically inserted in the connector bodies. At French manufacturer Socapex, for example, each of five machines inserts 50,000 contacts a day in edge connectors, each doing the work of three or four manual operators.

Taking hands off semis

In semiconductor assembly, until recently, cost-cutting efforts have been concentrated on going overseas for hand labor. But that has been getting less advantageous, according to Richard Abraham, vice president and assistant general manager for U.S. operations of Motorola Semiconductor, Phoenix. Labor rates overseas have been increasing much faster than in the U.S., he says, and tariff provisions 807 and 806 (the former covering products shipped overseas for final assembly or processing, and the latter covering products processed overseas and returned here for final processing) could eventually be modified in some way detrimental to the semiconductor industry. "You'll see a lot more assembly operations in the U.S. in the future," he predicts.

Coil winder. Machines at Grundig produce 300,000 high-frequency coils per day with 10% of the workers needed for manual operations.



If so, semiconductor firms will have to automate, and wire bonding is the process most likely to be automated first. "In the next few years, we'll see the end of manual wire bonding," Abraham declares. "It's been the dream of the semiconductor industry for years." Automation will improve uniformity, he notes, but it will also create additional demands on other processes to hold to dimensional tolerances, since human operators can more easily correct for misalignments in die fabrication and attachment.

One company leading the way in this area is the German member of the ITT Semiconductor Group, Intermetall GmbH. Horst Knau, Intermetall's plant manager, says machines developed by them for automated chip and wire bonding of plastic transistors are the fastest and most efficient around. Chip bonding is more than three times faster than manual operations, and wire bonding is more than 10 times faster, he says. Only one person is required to monitor two wire bonders. So, with 30 chip and wire bonders, Intermetall says it can turn out more than 100 million plastic transistors a year. To be handled by the automatic wire bonder, however, the transistor chips had to be redesigned with larger bonding pads, but Knau says this did not affect the chips' characteristics.

An automated lead-bonding process for dual in-line packages, informally called Auto DIP, has been under development at RCA Solid State division in Somerville, N.J., for the past two years, and is expected to be in pilot production at the division's Findlay, Ohio, plant by July. Arnold S. Rose, the RCA division's manager of hybrid and packaging technology, says the new process can assemble 3,000 DIPs an hour. "We hope to get up to 6,000 an hour, and the possibility of making one every half second [7,200 per hour] exists." Following testing at Findlay, the first system will be moved to the division's production facilities in the Far East, probably the middle of next year.

Companies the size of Motorola, Intermetall, and RCA may be able to afford the investments in in-house developed automation equipment, but what of the smaller producers? Motorola's Abraham has a warning

on this, saying that smaller producers will have to depend on outside suppliers whose equipment still will have to be modified to suit each company's needs. While he agrees that good outside wafer-preparation equipment is available, he still expects more of his assembly equipment will be built on the inside.

Motorola, for example, is making a "giant TO-3 maker." Leo Lehner, manager of power-transistor operations, says, "two machines will handle the whole world demand for these power transistors. It takes a while to make one [machine], but when it's done, stand back." The company is making similar equipment for plastic power transistors. Lehner adds, "We don't design equipment unless it triples productivity."

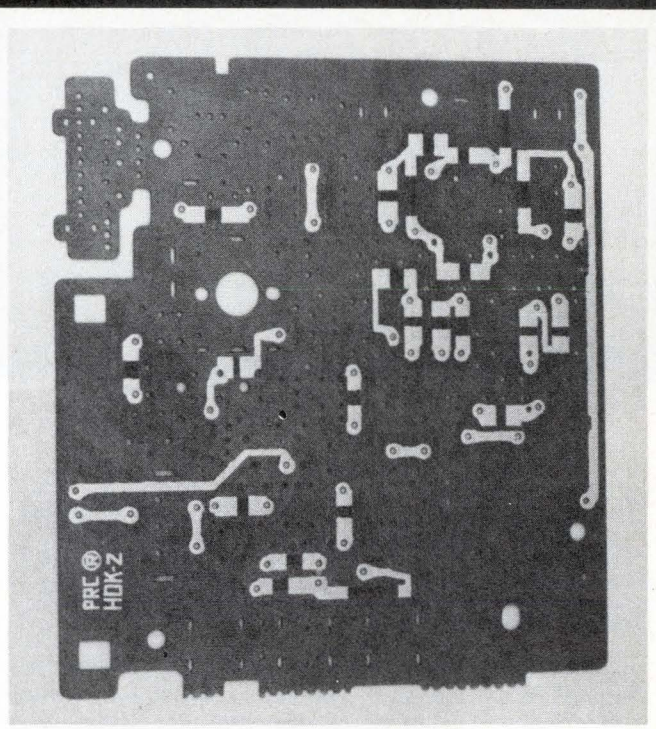
Automation brings reproducibility

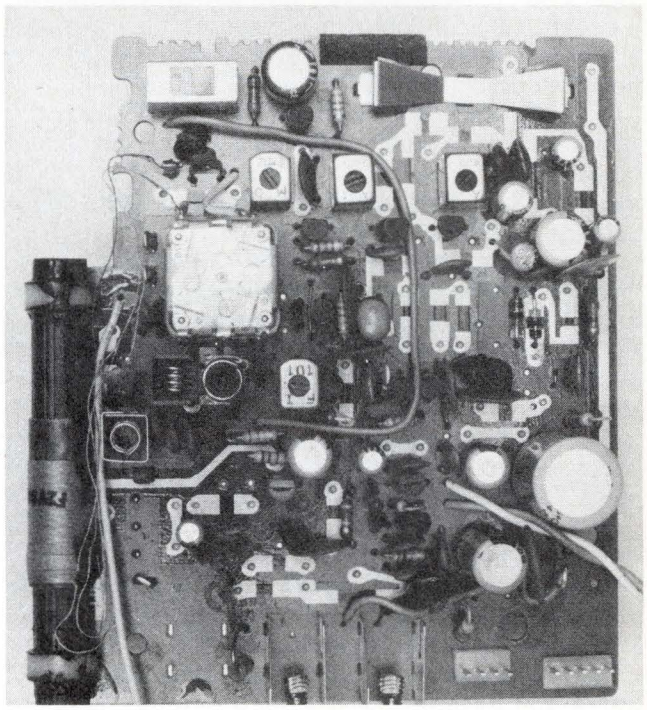
At Texas Instruments, Morris Chang, vice president and general manager of the semiconductor division, Dallas, points out that increasing chip yield was the primary reason behind TI going so far in mechanizing its fabrication shop. The more automation in the process, the greater the control and reproducibility over a particular operation, Chang says, and "that's important for high yields, especially in as complicated a process as manufacturing semiconductors. Of course, throughput can also be increased with mechanization, but improved yields, that's the key to productivity."

One big factor in yield loss is breakage—each slice must be examined carefully to see if it hasn't been cracked, chipped, or broken in handling. "Try to run a line, with 500 people," muses Chang, "and tell them not to break a single slice. It's impossible."

The solution for breakage, he says, is more automation and better handling equipment: "Keep as many operations as possible free of human handling." But Chang points out that it's almost impossible to mechanize the front-end fabrication in the sense that an automobile assembly line is mechanized—that is, all steps tied together in a continuously flowing process. "The trick," says Chang, "is to automate each discrete step and not worry about tying the steps together."

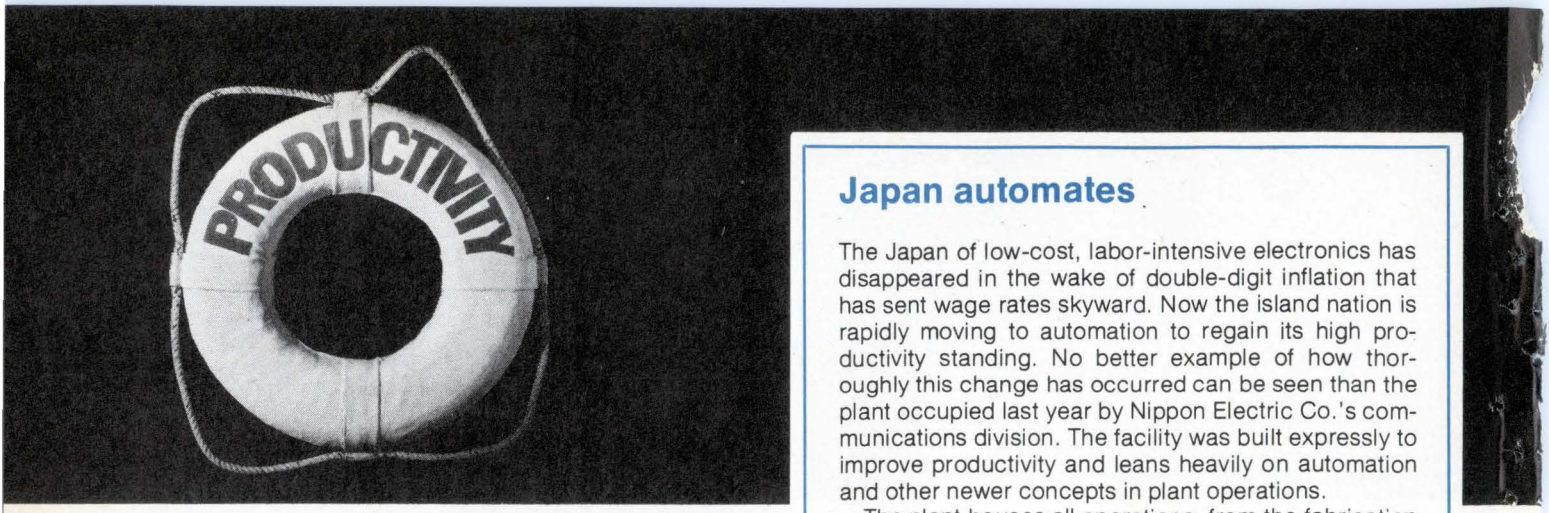
Tying the steps together in one big hands-off operation—in the front end, out the back end—is not feasible in semiconductor processing as several steps must be repeated and intermingled with other steps, all taking different times to accomplish. Here the procedure is fairly standard throughout the industry.





Tight fit. Radio circuit board built at Matsushita uses printed resistors (top photo) to ease space requirements where automatic insertion head must fit between densely placed components. Many of the parts on the completed board (bottom) are automatically inserted.

"In processing a slice," says Chang, "You use several basic steps over and over. In any one slice you go through various intermingled diffusion steps, photoresist steps, sputtering steps, ion-implantation, etc. The problem is that each of these steps take different times to process, and some are at high temperatures, while



Japan automates

The Japan of low-cost, labor-intensive electronics has disappeared in the wake of double-digit inflation that has sent wage rates skyward. Now the island nation is rapidly moving to automation to regain its high productivity standing. No better example of how thoroughly this change has occurred can be seen than the plant occupied last year by Nippon Electric Co.'s communications division. The facility was built expressly to improve productivity and leans heavily on automation and other newer concepts in plant operations.

The plant houses all operations, from the fabrication of special parts to the shipment of a variety of completed telephone equipment. It uses computer control of automatic equipment for several operations, including parts preparation, insertion, and soldering. Wire stripping, wrapping, and termination procedures have all been mechanized. In addition, automatic testing, and computer feedback have been initiated, resulting in a 33% increase in efficiency compared with the process at other NEC facilities

NEC's new plant features an automated warehouse and inventory control system, too. The system automatically places orders and manages inventory on the basis of equipment orders. The warehouse covers about 1,300 square meters and contains 6,500 parts trays holding over 100 million components.

To improve internal communications NEC has set up a production engineering unit connected with headquarters by a data communications link. In the future, the plant will have graphic communications.

others are run at lower temperatures, and so on."

"The point," says Chang, "is that these types of processes are incompatible both physically and in time. It would be foolish trying to tie them together."

Better yields pay off

Thus, except for mechanical assembly operations, automation in the semiconductor industry is rather spotty today. Unlike equipment manufacturers, who eagerly automate production lines largely to reduce labor costs, semiconductor manufacturers have been far less enthusiastic. Andrew Grove, a founder and vice president of operations at Intel Corp., Santa Clara, Calif., states flatly: "The semiconductor industry is not significantly more automated than it was ten years ago. Except for a few blips and notches in the growth curve and in a few limited areas, the industry has made no practical improvements in this area."

John Carey, founder and vice president of operations at Advanced Micro Devices, Sunnyvale, Calif., puts it this way. "It makes no sense for a company like AMD to run out and spend millions on automation when we can put our efforts into increasing yields on front-end wafer fabrication where our capacity can be doubled, tripled, even increased by a factor of ten. That's where this industry's money and effort goes—yields and new designs that increase the value of a chip by putting more devices on it. Nothing fancy—but for us, that's productivity."

Grove asserts that the factors having the greatest impact on boosting production in the last 10 years have been improvements relating to silicon wafer size, processing, and design. "On a scale of 100, these factors add up to 95—the remaining five points can be attributed to automation."

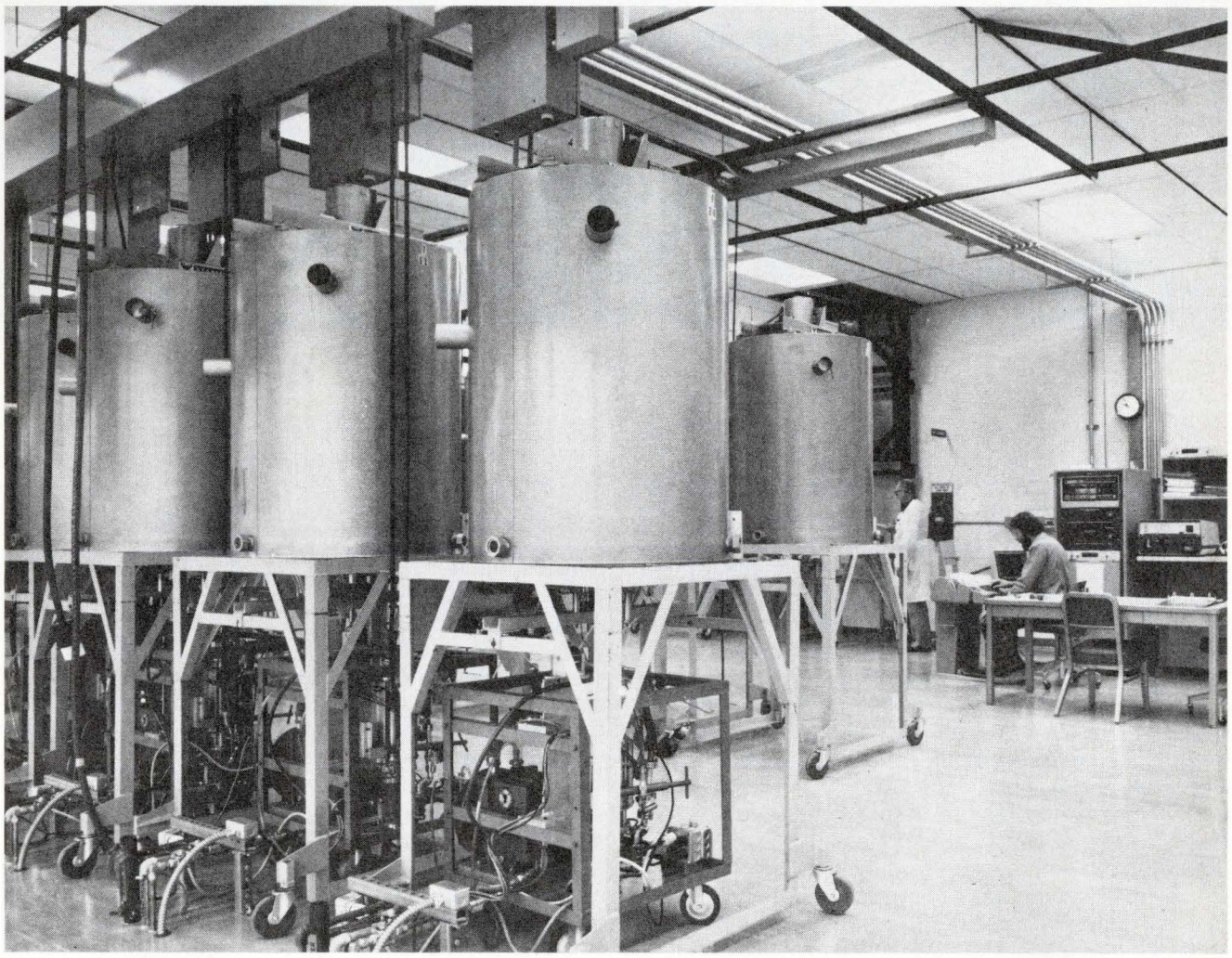
Consider this, he says: IC production started on 1-inch wafers, and they are now almost universally built on 3-inch slices—an increase of about nine times in usable area. Eliminating some of the edge waste, this means that with, say, a 1,024-bit RAM design, going from 1- to 3-inch slices increases productivity by a factor of at least six.

Says Grove, "it takes several hundred thousand dollars to scrap your old ovens in a production line for new ones, but if you can increase your capacity from five thousand units a month on 2-inch wafers to, say, 50,000 units a month on 3-inch wafers, then at, say, $5 a unit, you've paid for your oven investment in one month. Or you can reduce the number of ovens and people to run them by a factor of five for the same capacity. Now, that's productivity."

Printed-circuit boards, like semiconductor wafers, also involve chemical processing, but here things are different. Pc boards have long since taken advantage of size increases to give higher outputs. Manufacturers are already dealing with large areas of material, and non-fragile material at that. So automation to speed up the handling process can be important, if expensive.

The experience of Photocircuits Corp. in Glen Cove, N.Y., is a case in point. Photocircuits is putting the finishing touches on a new 70,000-square-foot plant in Riverhead, N.Y., which will use a fully-automated additive-plating system when it goes on-line late this year. Automating the existing plant in Glen Cove, however, was considered too costly, so manual processes have been speeded up by means of certain improvements at almost every step in the line.

At the Riverhead plant, production with the additive process will consist of cutting the basic panels, coating with adhesive, drilling, photoprinting (or screening) the conductor pattern, chemical activation, and plating. In Glen Cove, to boost drilling productivity, Photocircuits uses computer-optimized numerically-controlled drilling. Normally, an N/C drill tape is constructed from a digitized tape master, but at Photocircuits, the digitized



Elephant farm. Vacuum chambers at Tektronix are computer controlled for evacuation and sealing of cathode-ray tubes used in storage oscilloscopes. Units can be relocated, plugged into power sources, and run by one operator. Previous setups required two operators.

data is fed into a minicomputer which optimizes the hole pattern for the shortest wire routes. The computer then creates an N/C format tape and stores the drill-hole data for future use or editing.

At the printing step, semiautomatic and fully-automatic printers are being used to increase throughput. Conventional photoprinters pass the panel being printed in one direction as film resist is exposed. A special shuttle photoprinter allows two boards to be exposed by alternately moving them in and out of an exposure chamber. This machine doubles the photoprinting rate. For screened resists, a manual-loading semiautomatic machine increases production rates by 25% over manual screening and a completely automatic screener increases the rate by 50%.

At the Glen Cove plant, 15 workers process an average of 7,000 square feet per day through each of the plating steps. The baths themselves are controlled by an automatic system that checks the bath parameters and pumps in new chemicals when needed, thus replacing previous operators. Photocircuits' new facility at Riverhead will use all the improvements mentioned in N/C drilling and printing used at the other plant in addition to a fully automated additive-plating line. The plating line will turn out 7,200 square feet per day with only three people. In addition, the entire line will be in a controlled temperature and humidity environment to further increase yields.

Automated equipment production: output dictates the method

The printed circuit board has become the standard interconnection and mechanical support member in most equipment construction. Thus, with component mounting-hole dimensions standardized and with standard-sized components, there is a large market among equipment manufacturers for standardized automated equipment.

But even though automated equipment is commercially available, a company cannot afford to install the equipment and then forget it as components technology changes. For as technology changes, so must automation methods match the new types of components and equipment on the production lines. Vernard



L. Price, manager of mechanization at Zenith Radio Corp., Chicago, puts it well when he says, "For the fun of bragging that you're fully automated, you could lose your shirt." Zenith, the country's leading producer of color television sets, had heavily promoted a "hand-crafted" image for many years. Now Zenith has what is perhaps the most automated module production line on the American consumer-electronics scene, yet manual operations are not abandoned entirely.

Zenith's approach has been to:

- Not transfer all component-insertion procedures to machine; that is, avoid mechanization for its own sake.
- Continue to analyze and refine its system, which was originally installed in late 1972.
- Consider eliminating some machines eventually in favor of more economical hand insertion as ICs begin to replace other components on the modules.

"The main advantage of automation," Carl A. Petersen, executive director of TV-products manufacturing adds, "is that machines either make products all good or all bad, and it's easier to spot the problems and fix them than with production workers."

The conversion to a sophisticated automation program for this company represents the productivity game raised to the highest stakes—competition against imports and against domestic producers who use offshore facilities.

Zenith's showplace facility is its Plant No. 2, which some years ago had been earmarked for shutdown and sale. But the situation changed with the decision to fight back against the manual labor inherent in foreign competition by automating its own domestic operations (witness its later series of advertisements on the effectiveness of the American worker). Plant No. 2 is now producing TV-receiver and stereo-component modules with a potential capacity of 80,000 boards a day.

The brains of the line is a computer that produces the programs used by a series of on-site minicomputers to control automatic component sequencing and insertion. In terms of production, the crucial decision was to use 48 automatic machines made by Universal Instruments Corp., Binghamton, N.Y.

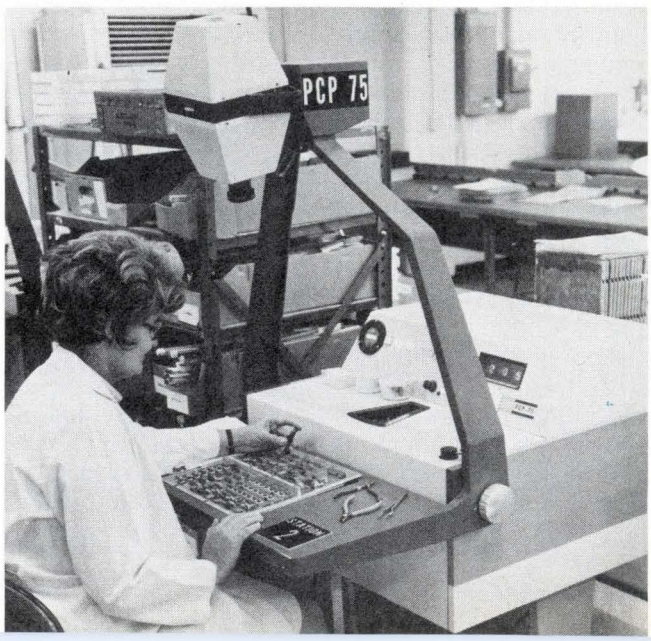
Designers had earlier introduced modular concepts to production, and then automated production requirements in turn forced Zenith to impose rather stringent standards on designers. Thus, today, engineers must observe limits on size of printed circuit board, type of component, and component spacing (including lead-hole dimensions).

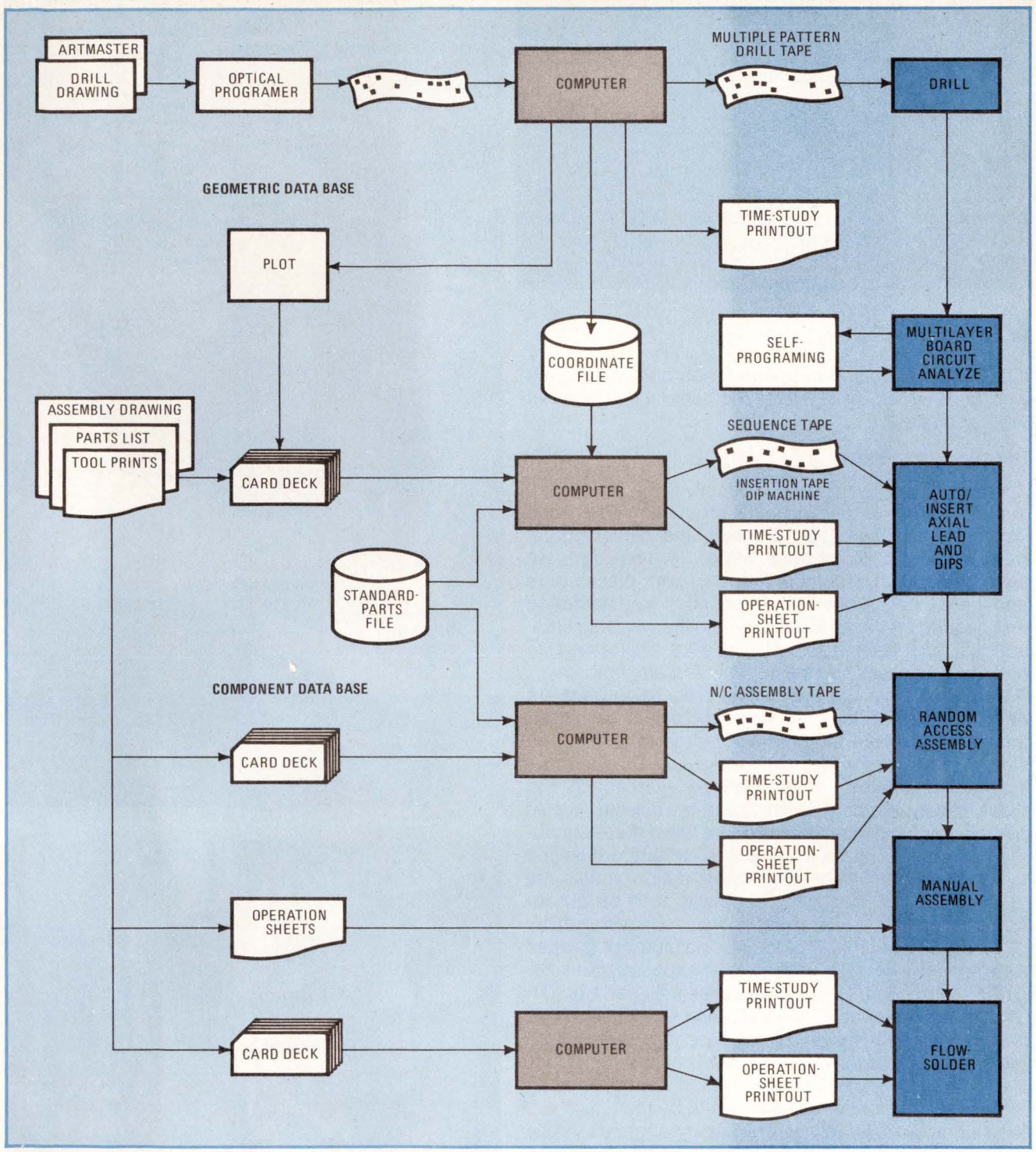
As part of the standards program it was important to find vendors who were able to supply axial-lead components that could be run through one of the 24 Universal Instruments sequencing machines at Plant No. 2. Computer programed, these machines prepare reels with up to 39 different components and jumper wires in the proper sequence for insertion by a variable-center-distance inserter, which is also computer controlled. One General Automation minicomputer usually handles two sequencers and two inserters.

Plant No. 2 previously used integrated-circuit socket-insertion equipment, but recently switched to direct mounting in soldered holes. Direct mounting, which saves money, does increase the cost of removing failed IC's but today confidence in reliability has now reached the point that direct mounting is considered economically feasible.

Zenith is far from alone in turning to automation to enable it to compete against imported TV sets. Observers had once predicted that Far Eastern imports would dominate West Germany's market, for example. But

Short runs. For short production runs, Airborne Instruments Lab uses Ragen Instruments semiautomatic machines, in which a light beam directs operator to the location for component placement.

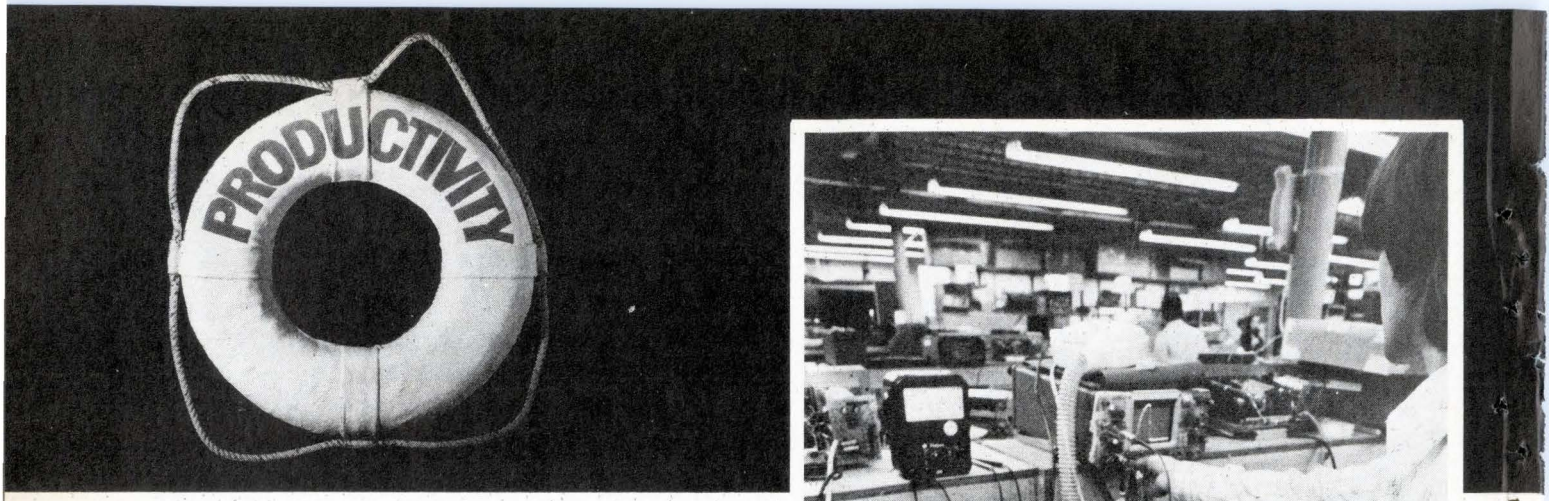




Single source. After printed-circuit artwork is digitized, computer at Bendix Corp. takes over to generate series of tapes used in such operations as pc board drilling and testing, and sequencing of components for automatic and semiautomatic insertion.

now, "We can sell portables of higher quality at competitive prices," says Herbert Bruch, in charge of manufacturing technology for Grundig AG. At Grundig's main plant in Nuremberg, a facility originally planned for a daily output of 1,000 sets now turns out more than 1,500 units each workday with the same number of people—making the company the undisputed leader in West Germany's color-TV market. Grundig's present share of that rapidly expanding market: about 20%.

Today, even small portable radios are being designed in Japan for automatic insertion of components. Transistor radios started out as compact products and designers felt it was better to use pc-board hole spacing appropriate for individual components rather than put the holes in a standard grid needed for automatic insertion. Now, at Matsushita Electric Industrial Co.



Ltd., radios are being designed for automatic insertion with grids of 2.5 millimeters, the same value used in television sets.

Reorganize the line

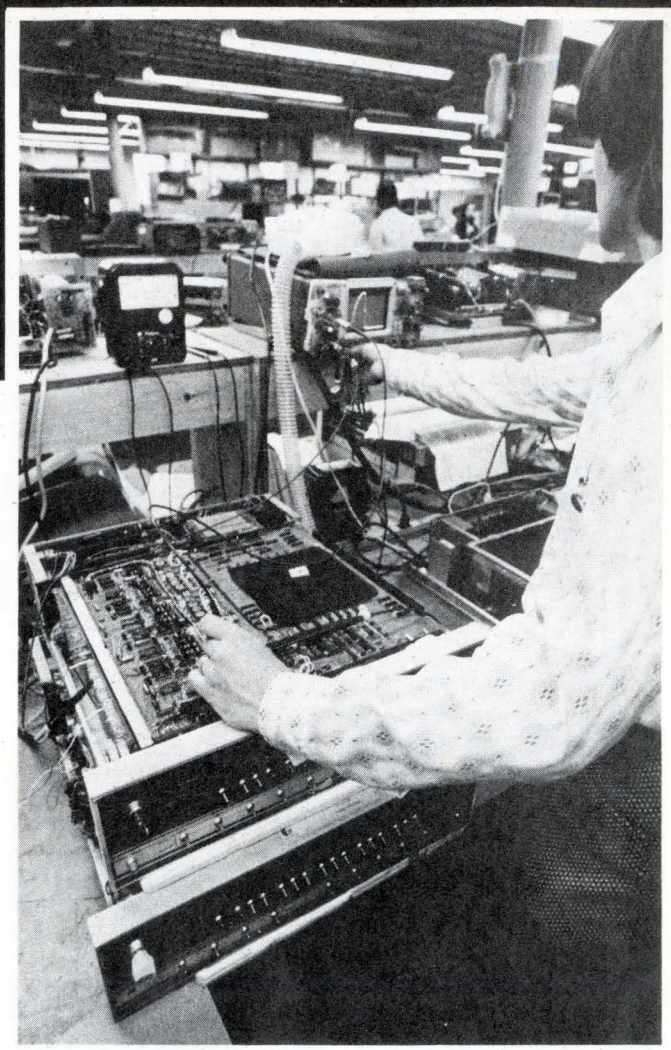
Another way to improve productivity on the manufacturing floor is to revise the production line itself. Take, for example, Data General, the minicomputer manufacturer in Southboro, Mass. "A year ago, we were set up like a cottage industry, with pieces here and there," says Robert M. Antonuccio, manufacturing engineering manager. But no more, he says. Data General last April set out to reorganize the final assembly and test processes and the conveyors were motorized.

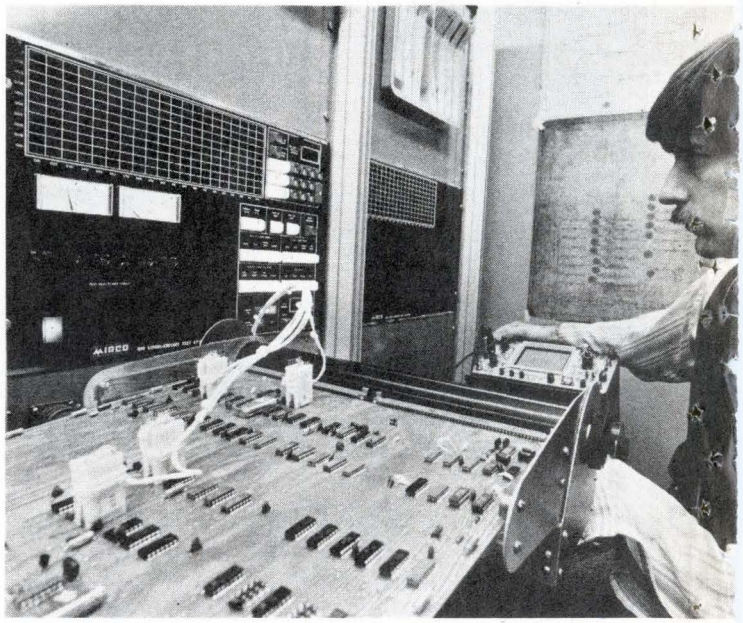
Today, all Data General central processing units are built on the same line. The motorized conveyors speed the line and make logistics a lot simpler, since they clearly show where the bottlenecks are. "We found," Antonuccio relates, "that when we tried to do too much minor assembly on the line, the whole line would be held up. It's difficult to balance a line if there are numerous operations on it." The line is therefore limited to a certain number of short steps; major chunks are built off the line and then brought to it to be put together. One line is given over entirely to final assembly of CPU's; Data General keeps no final stack of finished inventory but instead puts tested subassemblies together as needed. (Testing and assembly can't be differentiated, Antonuccio says. Testing of digital boards is now done at the lower, minor, assembly level, resulting in a lower reject rate at high levels of assembly.)

It's easier to lay out the production floor-plan when large quantities of one product are to be manufactured than when small quantities or a variety of goods will be made. But a close look can often reveal possible cost savings even on a relatively small production line.

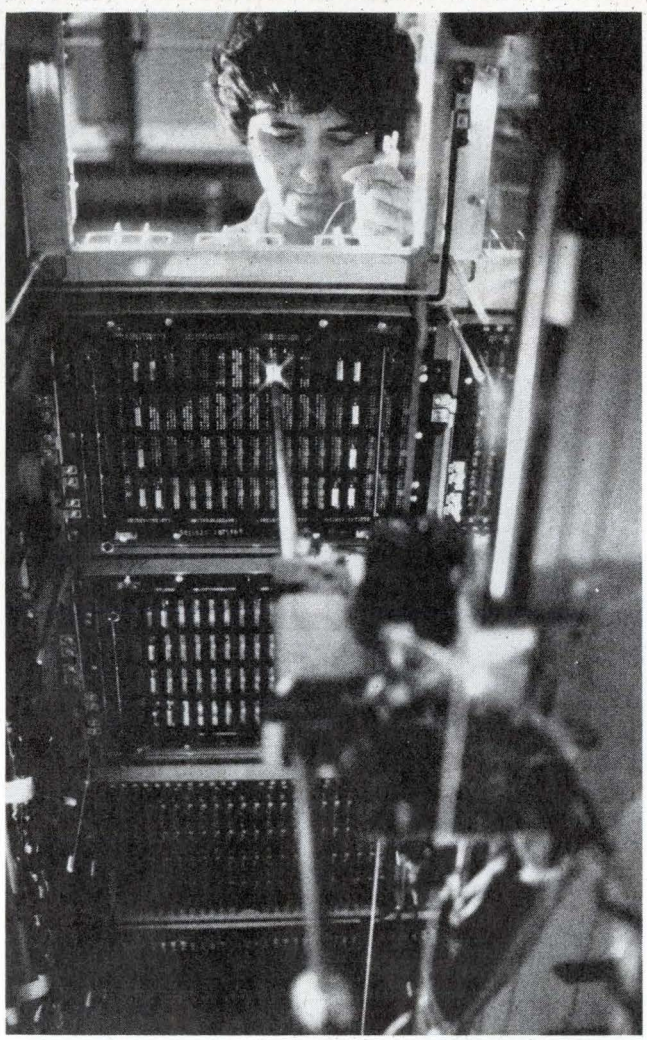
Hewlett-Packard's Colorado Springs division is attempting to cut costs by laying out its cathode-ray tube department by tube type rather than tube process. This may not substantially increase the number of tubes manufactured, explains division marketing manager Bob MacVeety, but it should cut down on scrap costs stemming from processing problems.

"Typically, with our kind of plant, you can go for two or three weeks before you find the mistake somebody made two or three weeks ago," MacVeety says. "Then





Testing. Before installing automatic test equipment at Data General, technicians used to troubleshoot faulty boards (top photo). Now, boards can be diagnosed by automatic tester (bottom), allowing better allocation of skilled workers and reduced training for operators.



Leading light. Computer-directed light probes (left) guide IBM wiring operator to proper location in interconnecting backpanels. Computer, which can automatically locate 280,000 points, also electrically tests connection before moving to next point.

you may have hundreds of tubes that all have the same mistake. But if you have a product-line basis rather than a batch-process basis, three days after you start making a tube it's finished. You can catch an error a lot faster, and you only have a few tubes in the pipeline."

Big plans for low volumes

Special automation problems arise when production runs are short and when design revisions are made while equipment is being produced. The effort involved in programing automated equipment can sometimes outweigh the benefits of more productive assembly. A prime example here is the avionics industry where often only a few pieces of certain types of equipment are built. But even here, automation, if wisely applied on a large scale, can boost productivity.

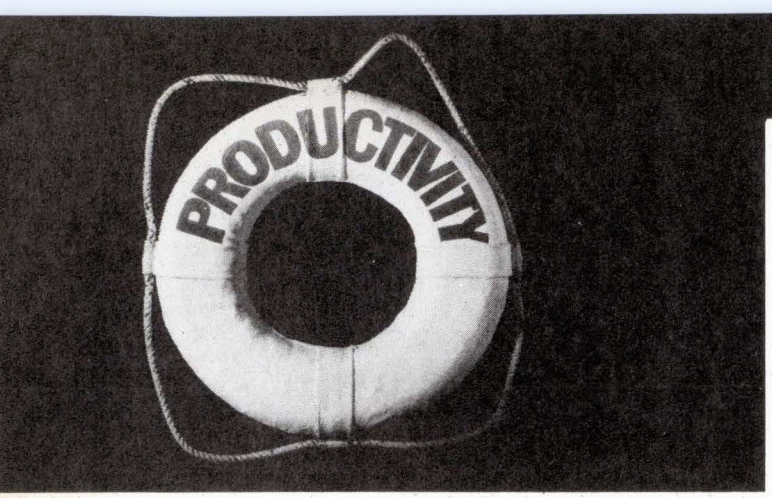
As its Teterboro, N.J., manufacturing facility, Bendix has instituted a computer-aided manufacturing flow that ties together automatic artwork generation, numerically controlled drilling, automatic and semiautomatic parts insertion, semiautomatic wire-wrapping, automatic test equipment, and computerized production tracking. This system allows Bendix to maintain minimum response time to product design changes and to keep track of many modifications of the same system traveling down the same production. Bendix, for instance, turns out a dozen versions of the DC-10 flight computer, each one for a different airline. A typical board passes through a mechanized three-level component-insertion process for axial-lead components, DIP packages, and miscellaneous discrete components. The board is then soldered, put on an automatic fault-isolation tester, functionally tested on special test equipment, then placed in stock.

Frank Schulz and Don Becknell of Bendix, who planned most of the automation, say automatic component insertion offers obvious advantages with respect to labor costs, throughput, error rate, and quality variations. Automatic insertion equipment also results in reduced rework requirements downstream. An automatic axial-component insertion device, for example, can install 6,000 components per hour to give a typical per-hour throughput of 38 component assemblies; dual-in-line insertion equipment can install up to 3,500 components per hour—an approximate per-hour throughput of 67 DIP assemblies.

Semiautomatic insertion equipment improves productivity and cuts direct costs by roughly one third over strictly manual techniques. Analysis has shown it is cost effective to switch from semiautomatic to automatic component-insertion for as few as six boards.

The majority of axial-lead components and all 14- and 16-lead DIPs are inserted automatically into the pc boards. The other components—including polarized capacitors, transistors, transformers, relays, and certain axial components—are installed manually with the aid of semiautomatic equipment. Actual axial component insertion is performed by a variable-center-distance, reel-fed Universal Instruments Corp. machine.

Obviously, then, not every company needs or can justify the completely automated manufacturing approach. Airborne Instruments Laboratories (AIL), Melville, N.Y., a large manufacturer of airborne electronic countermeasures equipment and ground-based instrument-landing equipment, provides another instance. AIL does not have the volume to require full automa-



tion. But because AIL is a large user of ICs in the flat-pack configuration, its engineers have developed a special machine to automatically insert and solder this hard-to-handle package. The Solo solder machine selects the desired flat pack from a storage position, orients it, and solders it to a pc board mounted on a X-Y table. Average daily output using the Solo machine is 400% greater than the older reflow soldering machine that required a two-step process of glueing the IC in place before soldering. Touch-up and rework has been reduced to 2%-3% from 10%-15%.

Automated testing finishes it off

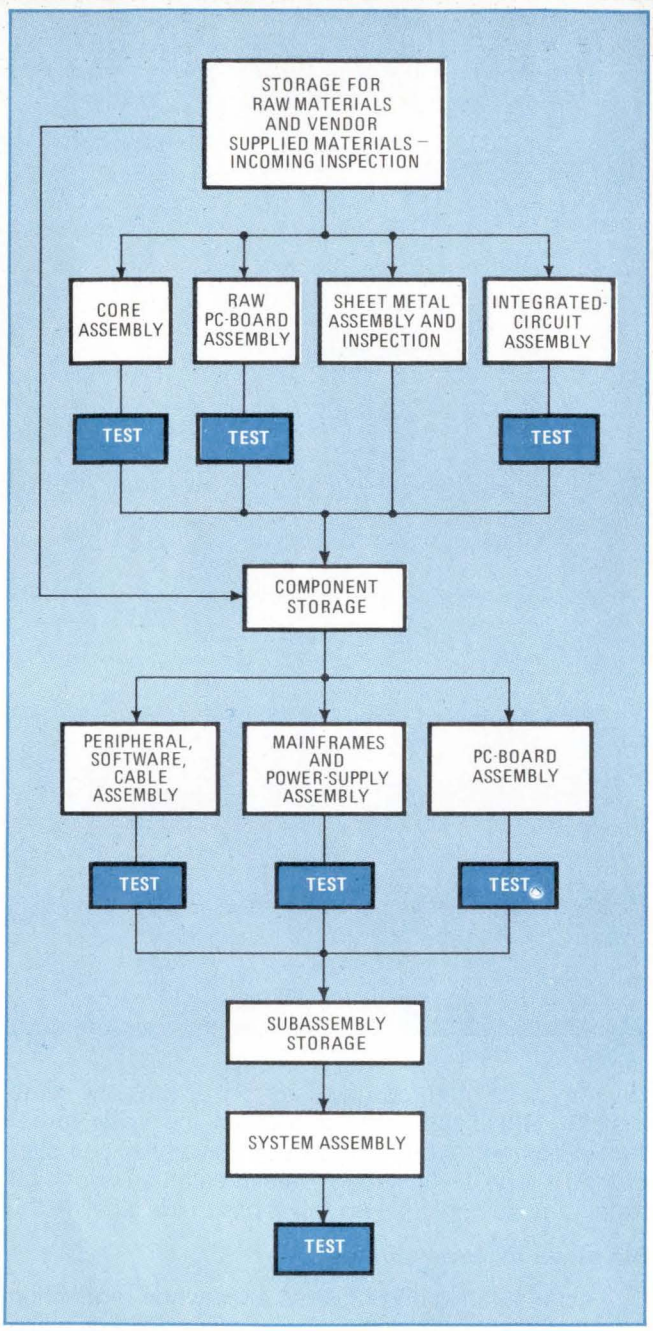
Automatic test equipment can substantially reduce the cost of troubleshooting and repairing electronic assemblies destined for integration into large systems. Sperry Gyroscope, Great Neck, N.Y., has installed three separate automatic test stands for checking out various types of assemblies, including printed-circuit boards, microwave equipment, and cables.

On a project currently under development at Sperry, Sheldon Kustin, quality engineering section head, says an automated system can handle 200 of the 300 board-types used. The other 100 are too complex or have too many input/output pins. One employee operating the system can check out the 200 automatically-tested boards in the same amount of time required for checking out the other 100 board types by seven technicians. While this isn't quite a fair comparison, says Kustin, it does illustrate why the automatic test system paid for itself in less than a year in service.

There are actually four levels of testing involved in equipment assembly: incoming inspection, board testing, final test, and field repair. According to Teradyne, Inc. a Boston manufacturer of automated test equipment, the cost of finding a bad IC at the incoming inspection level is approximately 33 cents. (It costs one cent to test an IC, and with a typical reject rate of 3%, the cost of testing 100 ICs to find three bad ones is 33 cents a fault.) If a bad IC is missed at incoming inspection and goes on to board testing, Teradyne says at this level it costs about $3 to find a fault. If a faulty IC isn't caught until final test, it costs $30 to find a fault, and if the IC fails in the field it costs about $300 to find it, including travel expenses for the field engineer.

At each level, therefore, the cost of finding a faulty IC becomes an order of magnitude greater, and this relationship holds true for other components. From this, Teradyne says, efficient, automated testing can in this way yield significant changes in output by reducing the time required to trouble shoot in the intermediate and late stages of production.

Automation, in the final analysis, is modern technology's prime tool for multiplying the effectiveness of labor. It cannot be forgotten, therefore, that the human being operating the machine, or watching over it, is an overriding factor in the scheme of things, which leads to the next section. □



Sub tests. Subassemblies for minicomputers built at Data General are tested after nearly every step to assure that final assembly will work properly, cutting diagnostic work on assembled computers.

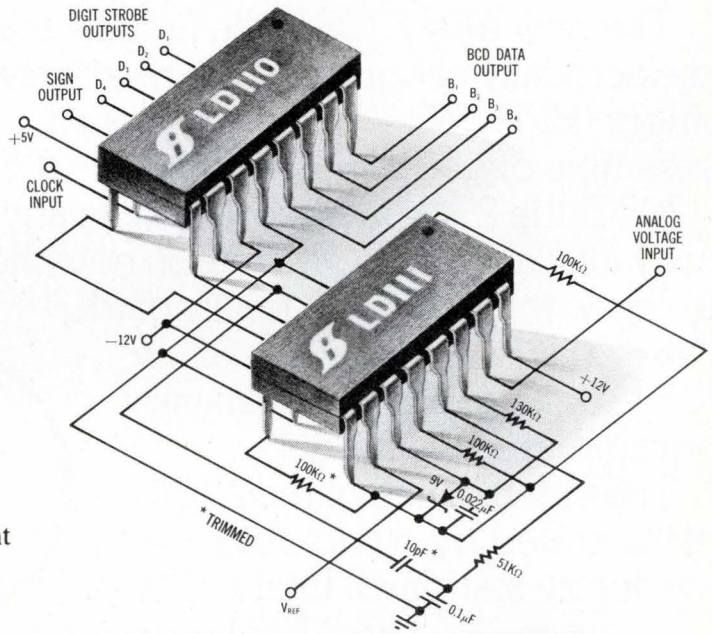
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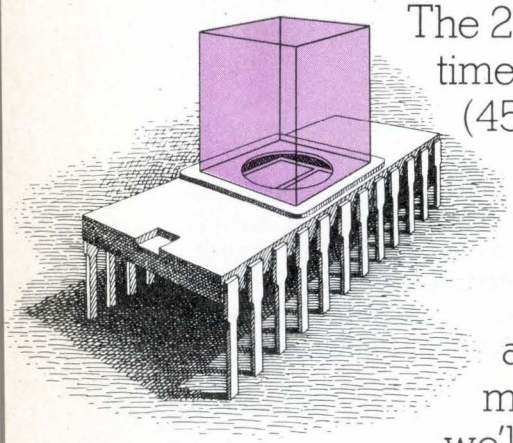
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Intel announ recyclable PRO



The new Intel 2708 is the first 8K erasable and electrically programmable read only memory (EPROM). With a guaranteed access time of 450 nanoseconds from 0°C to +70°C, the 2708 is twice as fast as any previously available EPROM. Intel is now the first supplier with a complete family of 2K, 4K, & 8K EPROMs and 2K, 8K, & 16K interchangeable metal mask programmable ROMs.

The significance of the 2708 is best illustrated by comparing it with the industry standard, Intel's 1702A.

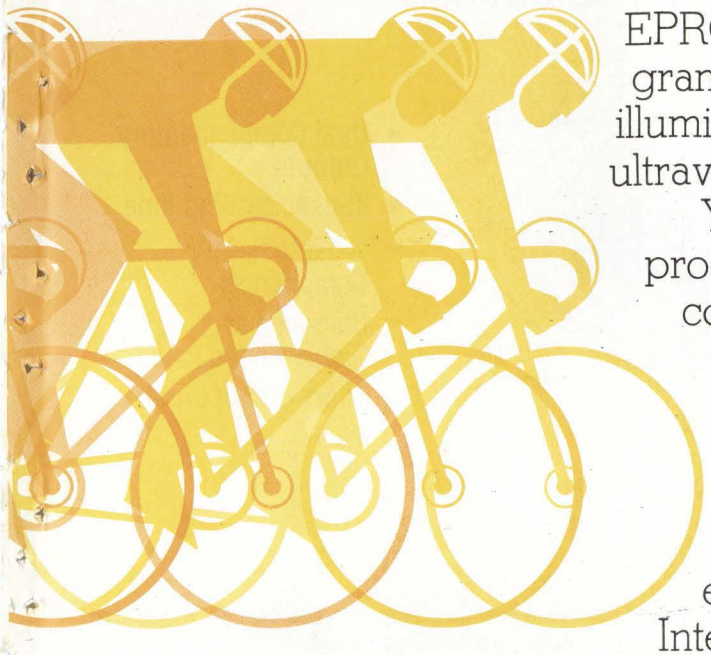


The 2708 has four times the density (8192 bits vs 2048), twice the speed (450 ns vs 1 μsec), consumes one third the power (95 μw/bit vs 300 μw/bit) and the 2708 programs almost five times as fast as the popular 1702A (12 ms/bit vs 58 ms/bit). All 8192 bits in the 2708 can typically be programmed in 100 seconds on any one of several commercially available programmers. With an order of 10,000 or more Intel EPROMs, we'll provide the programmer.

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Intel's complete family of EPROMs and bipolar PROMs are available from distributor stock. Most Intel distributors also offer free programming for prototype quantities. Contact: Almac/Stroum, Component Specialties, Inc., Cramer, Hamilton/Avnet, Industrial Components, Inc., Sheridan and L.A. Varah Ltd. For more information call any Intel regional office: West, (714) 835-9642; Mid-America, (214) 661-8829; Great Lakes, (513) 890-5350; East, (617) 861-1136; Mid-Atlantic, (215) 542-9444. For your copy of the new application note AP-6 "Designing with Intel PROMs & ROMs" write Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051.

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1K	3601-1 3601 M3601	256x4	16	50 ns 70 ns 90 ns*	OC OC OC	3301A 3301A M3301A
2K	3602 3602-4 3602L-6** 3622 3622-4 3622L-6**	512x4	16	70 ns 90 ns 120 ns 70 ns 90 ns 120 ns	OC OC OC TS TS TS	3302 3302-4 3302L-6 3322 3322-4 3322L-6
4K	3604 3604-4 3604L-6** 3624 3624-4	512x8	24	70 ns 90 ns 120 ns 70 ns 90 ns	OC OC OC TS TS	3304A 3304A-4 3304AL-6 3324A 3324A-4

*−55° to +125°C **Low Power

INTEL EPROMS

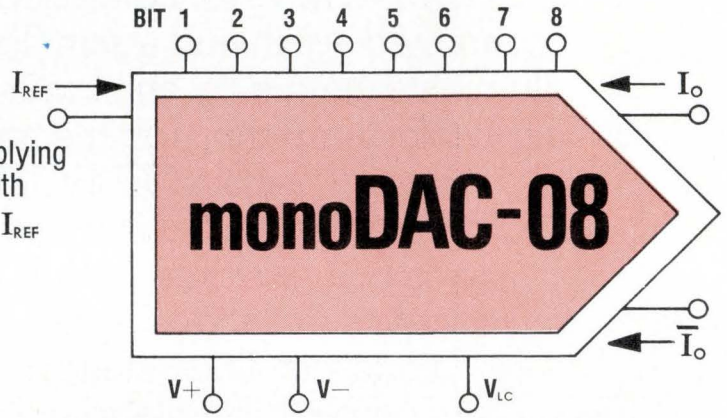
SIZE	PART NUMBER	ORGANIZATION	PINS	WORST-CASE ACCESS TIME (0° TO +70°C)	OUTPUT OPEN COLLECTOR OR THREE STATE	INTEL INTERCHANGEABLE ROM
2K	1702A 1702A-6	256x8	24	1.0 μs 1.5 μs	TS	1302 1302
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8K	2708	1024x8	24	0.45 μs	TS	2308 or 2316A

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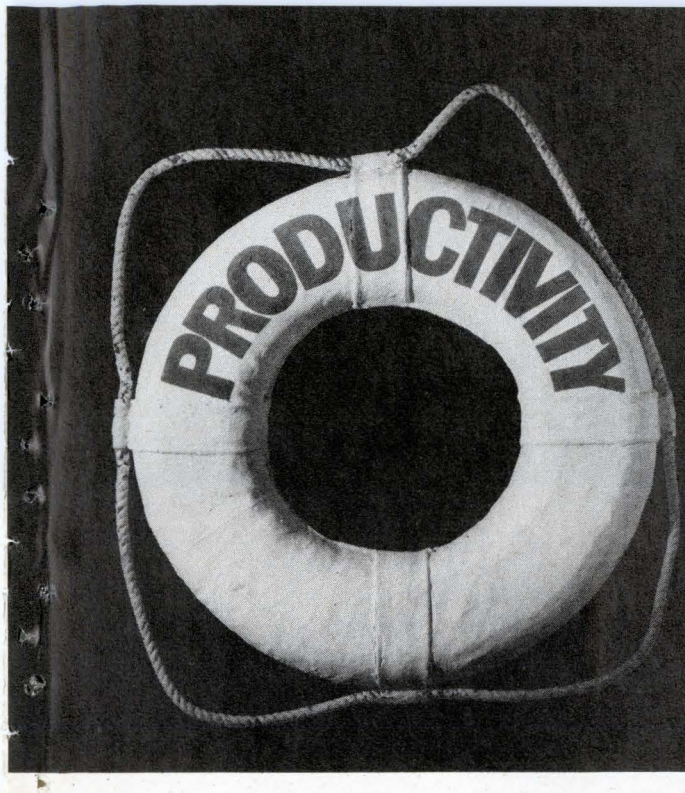
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Motivation means involvement

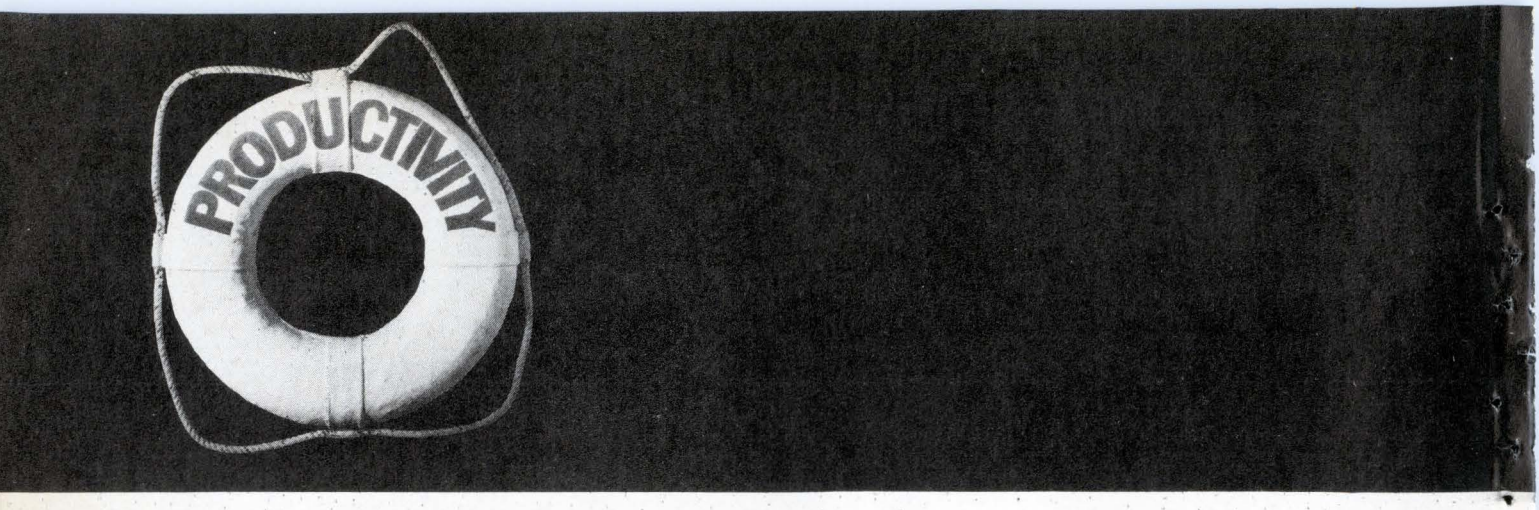
Participation by employees in company planning is the way to get today's workers motivated and to increase productivity; when setting their own goals, they try harder to meet them

☐ Vital to productivity improvement is the proper motivation of personnel—those at the engineering benches and in the management offices as well as those on the production line. Toward this end, progressive electronics companies have continued to explore for new incentives beyond the tried-and-true formulas.

Programs to "keep people happy" have been in use for many years and include stock options, bonuses, and company-sponsored fun and games. Also well established for many companies are systems to measure individual or group output against a set norm, with efficiency reports often prepared by computer. These might be called the traditional carrot and stick methods of motivation.

More recently, however, a growing desire by employees to have more of a say in what they do, and how they do it, has led to participatory programs. Highly publicized in certain segments of the automobile industry, the newer types of motivation have also reached electronics companies. In these firms, workers, managers, even union officials, share in planning and performance measurement. In short, communication creates motivation. As part of this movement, training programs have been opened to broader subjects involving company goals and improving performance. Electronics companies are learning that when employees help set their own goals, they feel more inclined to meet those goals and gain a greater sense of satisfaction than in carrying out dictated plans.

The new approach to motivation, reflecting the changed attitudes of today's worker, is as important in tradition-minded Europe and socially-conformist Japan as it is in foot-loose America. It's as important to highly



automated operations as it is to labor-intensive assembly lines. As a result, plant operations at, say, Philips, Matsushita, Texas Instruments, and Hewlett-Packard probably have more in common today than at any other time.

Decontroling employees increases output

The motivation program that has evolved at Compagnie Belge de Radio et de la Télévision (CBRT), a 70% owned Philips subsidiary at Bruges, Belgium, has had, for example, a direct effect on productivity. CBRT is the major supplier of color television receivers for Philips with a capacity of about 360,000 units a year. With about 2,200 employees, CBRT's productivity has been one of the highest in the Philips system since it was built in 1957.

Rapid expansion and the need to adjust to changes in TV-receiver designs, led to a radical change from the traditional assembly-line setup to a production-group concept. Critical of traditional production methods, which emphasize short work cycle and controls, Lucien Hautekiet, plant manager, began the restructuring in 1970.

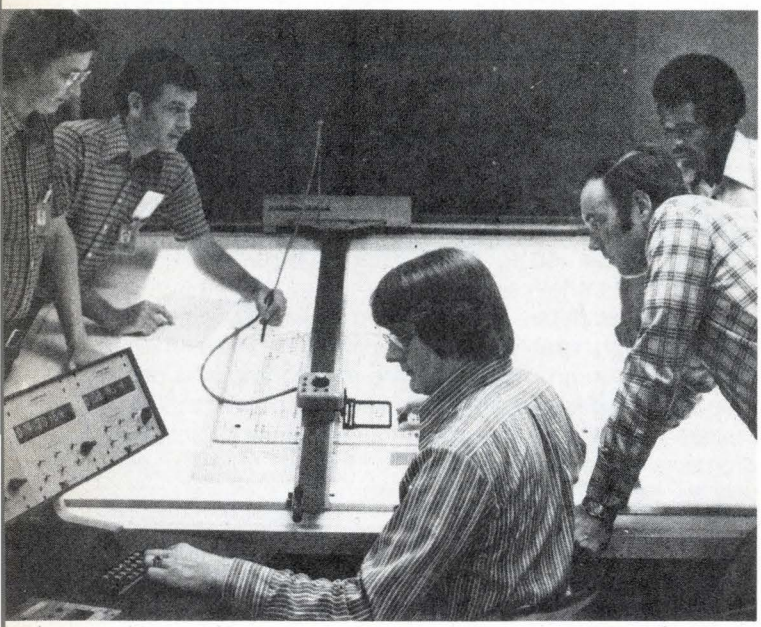
"Controls create reaction against control," he observes. "If the organizational structure is such that the worker is properly motivated, in theory the need for control should disappear."

The CBRT plant is organized into nine TV-set production groups—each one doing its own complete set assemblies—plus three other production groups that produce subassemblies and another one for cabinet decoration. Each of the 13 production groups operates as a miniature factory, and each is overseen by a production-group leader. The leader in turn has three to six subordinates and together they constitute the product team. The product team is responsible for efficient internal operation and for contacts with staff departments (materials handling, purchasing, personnel, etc.). Staff-department members, meanwhile, spend a certain amount of time each week on the production floor, a practice that fosters greater intimacy with production processes. As Hautekiet explains: "Staff people tend to think in theoretical, long-range terms; but for the product leader, the main concern usually is how to solve a particular problem immediately."

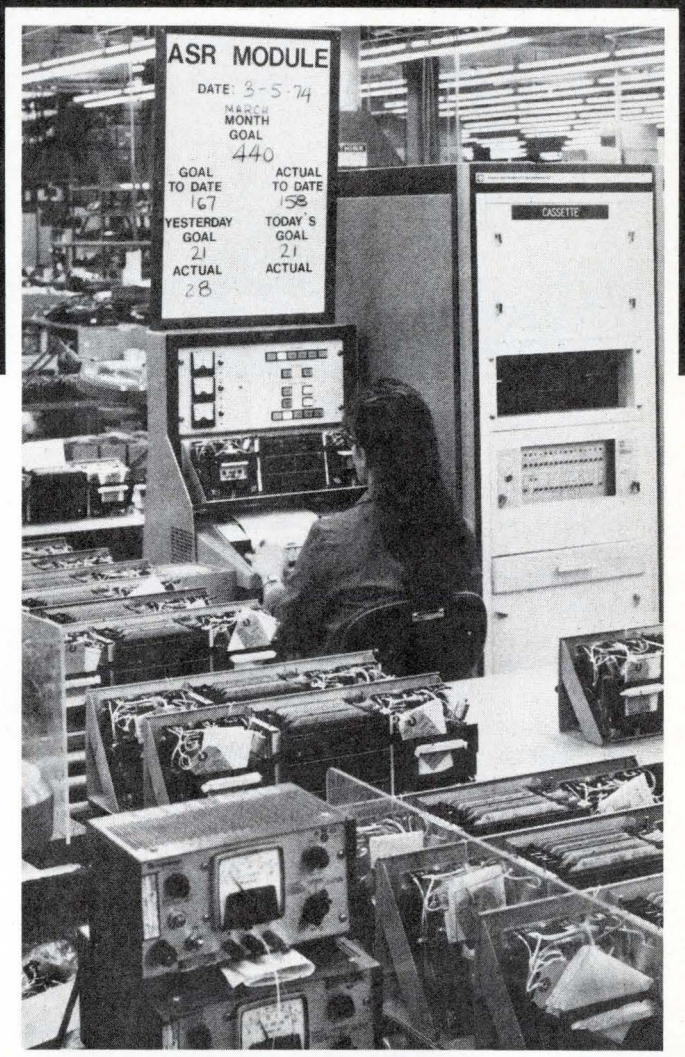
The production group is divided into sub-groups, each made up of 15 to 30 people and headed by a sub-group chief. Each sub-group is responsible for particular operations like panel assembly, inspection, fault tracing, repair, and picture-tube adjustment.

Six times a year the system is supplemented with two-hour consultations between workers and management. These sessions cover the work of sub-groups, production groups, the Bruges factory, and the entire Philips television business—all based on the belief that the broader the understanding of the product being assembled the greater the motivation for workers. And, to repeat, the CBRT plant has one of the highest productivity rates in the Philips organization.

A disadvantage of the Bruge system is the duplicate stocking of components for each product group. However, the new arrangement has cut the number of hierarchical management levels from five to three. And shortly after the shift to the new system five years ago, workers suggested that certain control steps could also be eliminated. The suggestions eventually were



Teamwork. The Work Simplification Program at Texas Instruments saves money and improves productivity by encouraging employees to "work smarter, not harder." This team at the Digital Systems division has saved some $400,000 on pc-board fabrication.



adopted, saving approximately 10% in assembly time.

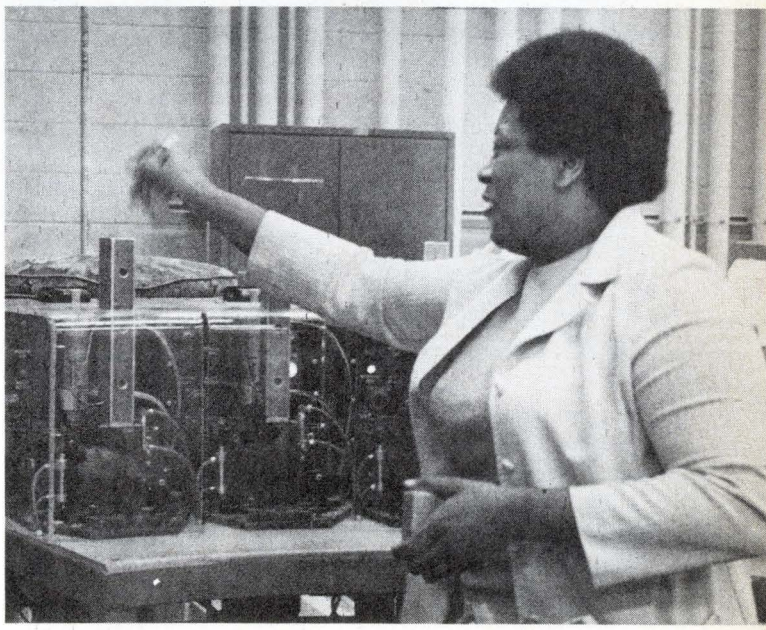
TV-chassis design changes also played a part in making the CBRT system work. The changeover occurred at the same time Philips developed modular sets, a design that facilitated the product-group concept. Coordination of design engineering and production may go even further. Design effort has been directed at increasing the number of functional units in the individual receiver to make individual or group assembly more suitable. As Hautekiet explained it to Philips personnel: "We have been only too glad to use the possibilities offered by new techniques in order to switch from process-oriented to product-oriented production, and this has led to advantages impossible with the old system, including choice by the worker of the speed which suits him best, personal influence on quality, and joint consideration of improved work methods."

Motivation works for any product

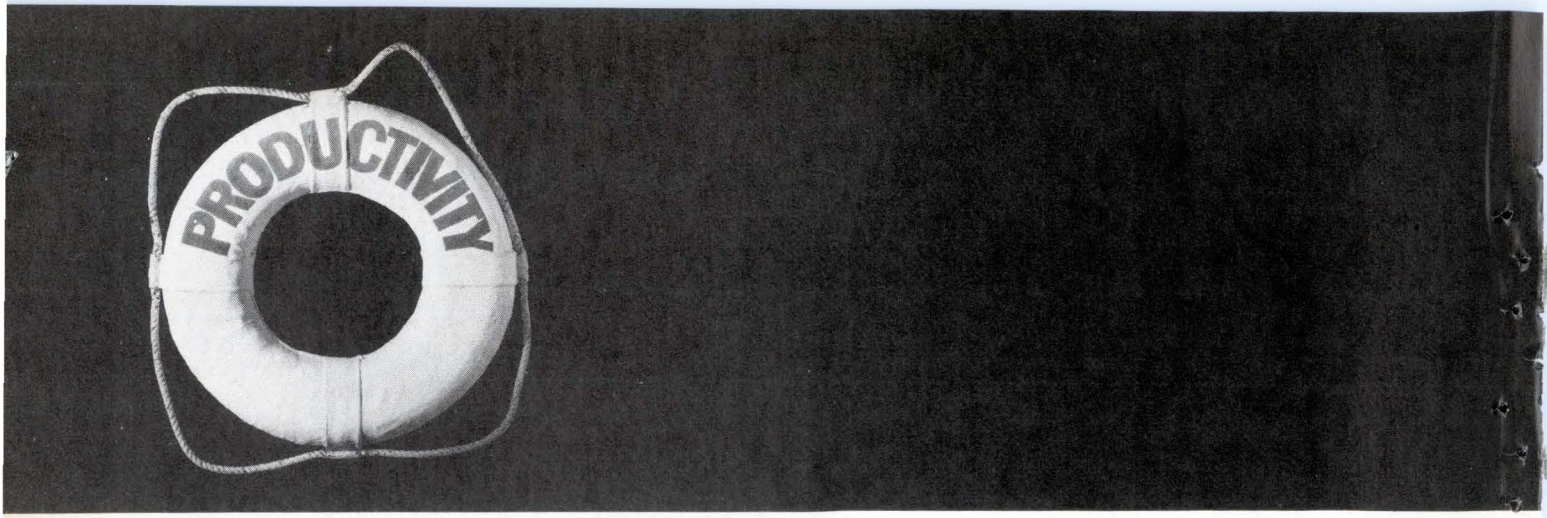
Employee motivation is equally important for highly-automated components makers and for firms dependent on complex manual operations, like computer companies. As it turns out, workers who run high-speed computer-programed machines can influence productivity as effectively as workers who do manual insertions, soldering, or other individual procedures. Some electronics companies have recognized this fact early, while others have learned it the hard way, i.e., after finding that the most up-to-date tools are not necessarily useful when in the hands of indifferent employees.

"The thing that makes it all happen," says Allen-Bradley's Stanley Kukawka, sweeping his arm to include people and machines, "is the attitude of the company from management to production line. And that doesn't happen haphazardly—some people call it management by objective, but it's also management by commitment to that objective. When the guy who does the job sets his own objectives, he puts his reputation on the line."

Similarly, employees at General Automation are meant to feel personally associated with the parts they make. To this end, a tag is attached to every circuit board instead of an entire lot. "This way the tag clearly states what board it is, and what has been done, as



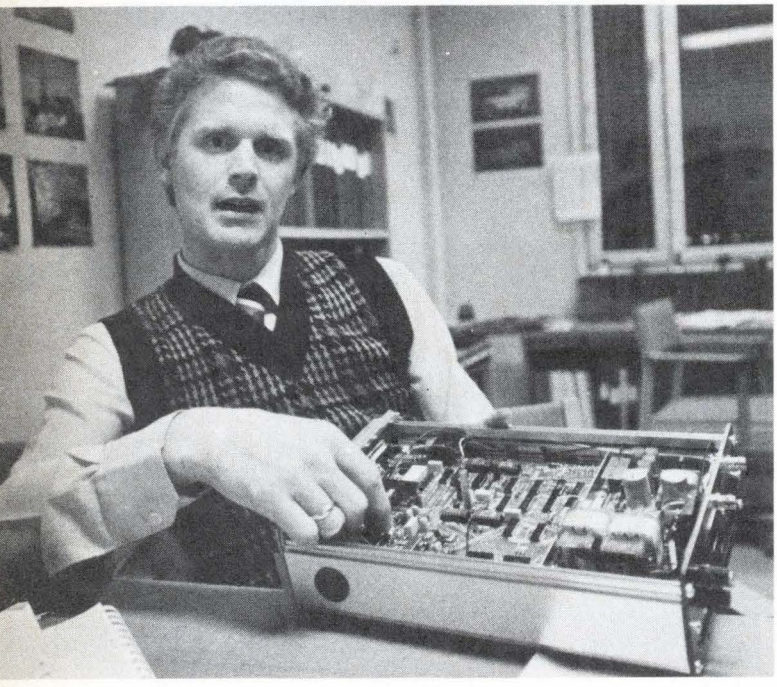
Keeping track. How well workers meet output targets is a key indicator of motivation. At a Texas Instruments plant (top) employee teams track each day's completed instrument panels, while at Chrysler-Huntsville (bottom) "pay points" are set at test stations.



well as who worked on it. We've found that the operators want us to know who does a good job, and this system provides accountability," explains William J. Mann, senior vice president of operations.

James Fisher, describing the long-standing employee motivation program set up by Texas Instruments, where he is head of the People and Assets Program, concurs on the value of worker self-esteem. "Usually people who set their own goals without exception set them higher than if these goals are set for them." They don't always make the goals, he adds, but, "it does a lot for motivation and gives us a lot more new ideas."

At TI the motivation program is called TIP for Team Improvement Program. The TIP scheme centers around teams of five to 10 people, sometimes as many as 30. Headed by their own chosen leaders, the teams set their own goals in terms of yield and output per week and track their own progress. Team members meet once a week, discuss what they've accomplished, how it compares with original goals, and what might be done to improve performance.



Results. "We like workers to know they're responsible for their work," says Wim Hazenberg, production manager for Philips Industrielektronik in Sweden. "A person who assembles an instrument should know what's really important. Otherwise we've failed."

A team of five wire bonders and five chip bonders, for example, may find that the die-bonding procedure is incompatible with wire-bonding outputs, that is, some dies must be reattached while the bonders wait idle. A suggestion might be made that the wire bonders learn die bonding so they can fill the gap in the team's output. "This very situation came up a few years ago," Fisher reports. "As a result we cross-trained a few wire bonders to do die patch work." The team concept has also produced good suggestions on changing the physical location of equipment so the flow of materials is improved.

Instead of an employee-suggestion program at TI, initiative is encouraged through merit increases, promotions, and the company-wide profit-sharing plan. The thinking behind this policy holds that the group which happens to be assigned to a new job usually has the greatest opportunity to suggest money-saving ideas. This being so, the group would have an unfair advantage over the people working on older products that offer little opportunity for cost improvements.

At TI's Digital Systems division in Houston, operating systems manager Patrick Weber cites one case of employee initiative leading to savings of $400,000 in one year. A group of draftsmen had worked on a new specification for laying out densely packed double-sided printed-circuit boards. On their next job—laying out far more expensive multilayer printed circuit boards used in the company's data terminals—the group recognized that their earlier work could be applied again. They were able to convert all the multilayer boards to double-sided boards.

TI also uses, at each plant location, strategy managers who set over-all policy for the facility, and tactical program managers to carry out the policies. Implementation includes a six-hour videotape presentation for new workers, with the videotape being followed up by a supervisor who spends several more hours initiating the worker in specifics of a particular operation. Later, Weber says, it's not unusual for a supervisor to gather his group in a conference room and disassemble a piece of equipment to discuss better ways it might be

Hewlett-Packard: motivation is its middle name

Long noted for keeping a happy shop for engineer and production workers alike, Hewlett-Packard Co., Palo Alto, Calif., has achieved a level of production efficiency that can't be explained by automation alone. By stressing the importance of individual actions on achieving company objectives, by rewarding performance, and removing frustrating obstacles, the test-equipment and calculator company has substantially increased the productivity of its work force.

"In many respects, I think we've tried to have high productivity just by having good people," says Hal Edmondson, Colorado Springs division manager. "We sure haven't done it by trying to invent simple products," he remarks, referring to the complexity of most of H-P's products.

The typical product is produced in relatively small quantities, which makes all-out automation unnecessary. Motivation, then, is an important part of what makes the company tick. "You structure the environment so employees can have some freedom to make contributions," says John Young, corporate executive vice president. "You take the hassles but of the day. That's the way you create an achievement-oriented environment."

Easier said than done, but in practice it seems to work.

The company also has an extensive profit-sharing plan, although it is not as generous as others in the industry. At the same time, efforts are made to engender team spirit to avoid what Ed Shideler, general manager of H-P's Loveland facility, calls an "individual incentive mode." In other words, while individual effort may be encouraged through salary increases and promotions, team effort is deemed necessary, too.

Something that occurred at the Advanced Products division in Cupertino, Calif. indicates the success of this thinking. Production rates there were high enough to earn staffers the nickname, "Flying Tigers." "When we moved into this building," recalls Clyde Coombs, manufacturing manager, "I had some posters made up that said 'welcome APD Flying Tigers' and the next thing I knew, this thing had caught on to the point that we have posters all over the place." Employees enamored with being part of the Flying Tigers team then asked if they could make up embroidered insignia to sew on their work smocks. Coombs, afraid that things might have gone too far, at first hesitated to budget $2,000 for patches. At a staff meeting, however, Board Chairman David Packard listened to the request, declared it "a beautiful idea," and Coombs went ahead with it.

Once employees are pulling together, H-P believes in removing minor headaches that may discourage initiative. One change was made in the working hours. H-P permits most workers to choose any starting time between 6:30 and 8:30 in the morning, take a half-hour for lunch, and leave after an eight-hour working day. The arrangement allows more flexibility for employees to schedule their home lives, or simply to choose their hours according to individual preference.

Flexible hours seem to be effective despite initial concern among supervisors that it would be difficult to monitor. Says Shideler, "It hasn't hurt. And given the improvement in attitude, it must have helped."

Hewlett-Packard also makes an effort to eliminate unnecessary restrictions on the assembly line. Most assembly lines at H-P, for example, are missing most of the drawings, schematics, and wiring diagrams found on many production floors. Instead, assemblers work from samples of the unit under construction, choosing their own methods for putting it together.

In addition, each assembler usually works on more than one unit at a time, deciding how much of one unit to construct before going on to the next. One assembler may choose to build a complete instrument before working on a second, while another may choose to build a part of each instrument, then complete each instrument.

The goal is to eliminate work rules when they might actually slow production or make it more tedious. By the same token, to save engineers time, H-P uses materials experts whose responsibilities include keeping track of availability and price of components and other purchased parts as well as liaison with H-P purchasing agents and vendors. Fred Pramann, manager of materials engineering at H-P Santa Clara division, says the materials engineer "is a specialist in certain categories of parts. He's there so the designer doesn't have to keep a whole bunch of catalogs, or worry about keeping up with prices. And so when the supplier comes to Hewlett-Packard he doesn't ask the receptionist, 'Who do you think might be interested in my product?' "

Company-wide, there is one materials engineer for every 30 designers. The designers, of course, retain the right to make ultimate decisions on which components to use. But they are spared much time in getting the information they need.

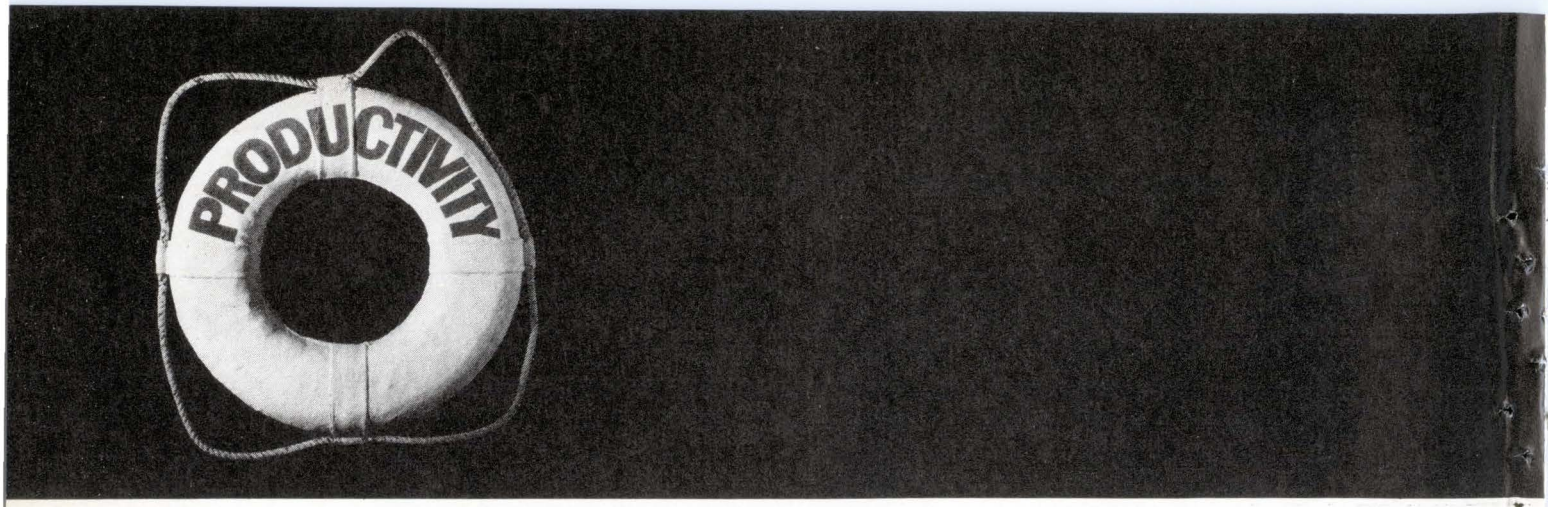
On the whole, the success of H-P in dealing with its people comes from recruiting the best personnel it can attract in the first place, especially engineering talent. Executive vice president Young adds, "You only let good people go recruiting. People who recruit bring home people who look like they do—so you get your top people involved in making important personnel selections."

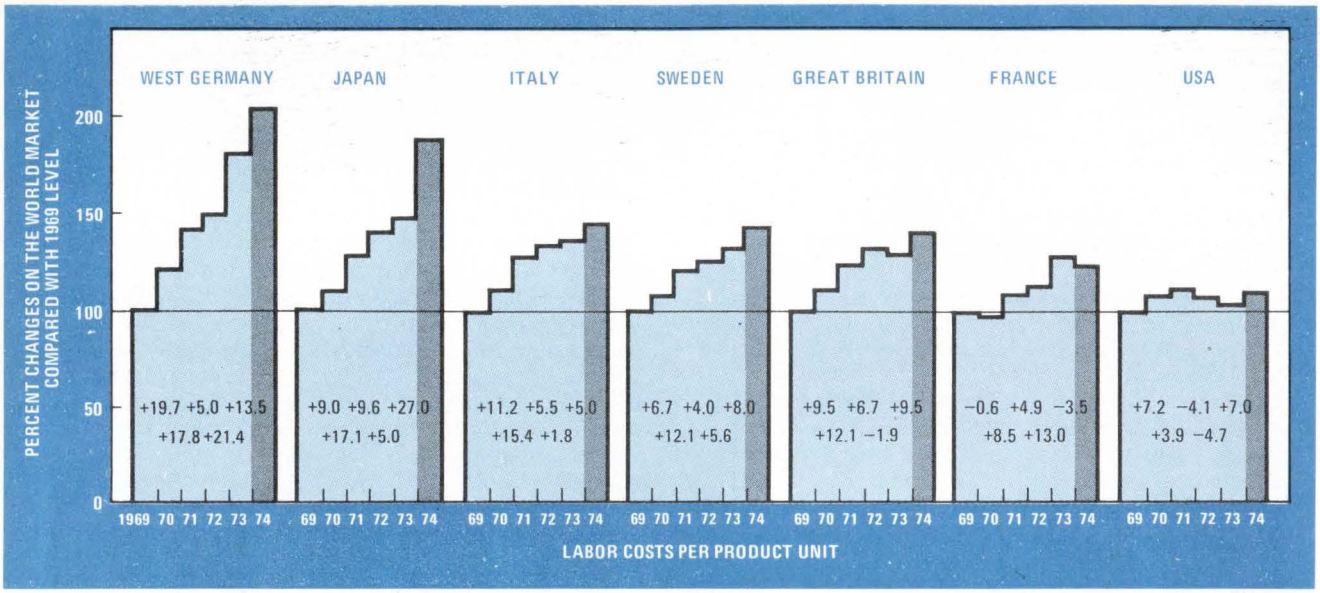
produced, stimulating new ideas from employees.

Even for the highly-automated operations, such as Zenith's module plant described in the preceding section, employee participation has become increasingly important. About two months ago Zenith started to organize a team effort in production. As with any automated line, changes in output or introduction of a new model play havoc with productivity. Steady, high-volume runs work best, but when this pattern is upset, there's trouble.

For Zenith, trouble had been new-model time. Now, bringing in a new model begins with a joint task force made up of a production supervisor, manufacturing engineer and an engineer for test and analysis. Their job is to come up with a plan for organization and control for the model line.

This task force works next with the operations manager to set up the line. At this point the plant manager enters the picture to confer with the plant superintendent. Finally, the general foreman, foreman, production workers and their union representative are brought in to acquaint everyone with new processes, and to re-





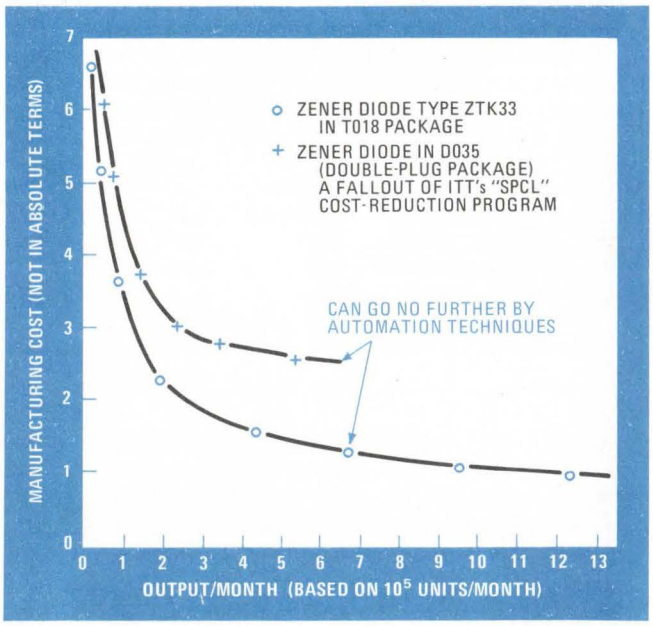
Output race. West Germany and Japan are well ahead of the other major industrialized countries in per-unit labor cost, according to this Siemens chart. Even though automation has been a key factor, motivation of workers is also crucial in these countries.

solve possible grievances before production begins.

"At first blush," Zenith's Carl Petersen observes, "the indications are good. This plan is giving initiative to the workers and foremen to solve problems at their level rather than sending them up the organization line. The success of any company is in the hourly work force—if you don't have their cooperation, you don't make it."

In Germany, Intermetall's effort to raise productivity also goes beyond automation. At the assembly line level, Intermetall has a productivity suggestion program. Suggestions are analyzed for practicality, patentability, and cost factors, and are rewarded accordingly. Payments have run into the thousands of marks for suggestions that have proved patentable. Sometimes a non-usable but seriously considered suggestion is rewarded by as much as 50 marks in recognition of the employee's interest.

Intermetall's salary-incentive plan is also considered important for motivation, with norms established by job analysts in cooperation with labor union representa-



Falling returns. Another reason motivation has become vital even for highly automated components manufacturers, like Intermetall in Germany, is that the return in productivity from new plant investment eventually gets smaller, as this chart on diodes shows.

tives. The established figure represents 100%, and percentages of output above that figure result in corresponding wage increases.

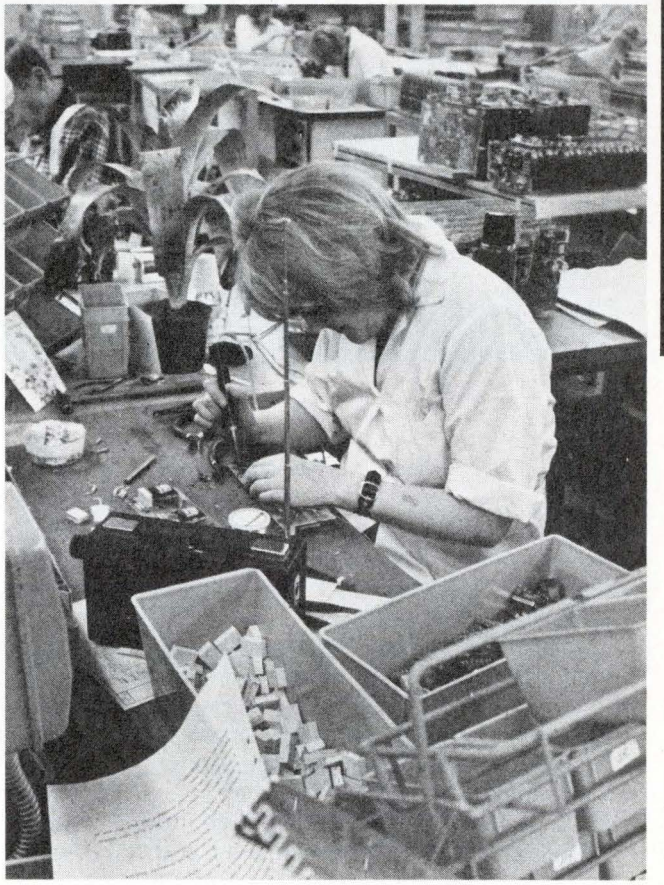
When aerospace turns automotive

Productivity efforts at the Huntsville Electronics division of Chrysler Corp., derive from a unique blend of the division's aerospace past and its high-volume automotive electronics present. Had it not been for its ability to design and manufacture in high volume, Huntsville division would never have been able to make the conversion from government contractor to Detroit supplier. The key was improvement in productivity.

The pay-point system originally developed by the parent auto company for assembly lines was adapted by the former space division in the early 1960s. Pay points are locations on the production lines that represent completed steps. They are also test points because the system is based on a comparison of acceptable parts produced with total hours paid to produce them. The result is "earned hours." Efficiency is rated by dividing earned hours by actual hours.

Production management gets a daily computer printout of direct labor efficiency. The printout lists part numbers, name of the part, the pay point responsible for production, quantity of accepted parts for the preceding day and month to date, the actual hours and earned hours for the day and month to date, the standard hours previously estimated to make that piece, and the day's and month's efficiency percentages. The report isolates trouble spots for the foreman and assigns productivity ratings to both workers and managers. If efficiency is below normal, the foreman checks workmanship quality, and parts quality. The system keeps tabs on outside suppliers, too, by catching on the assembly lines part failures that slip through incoming inspection.

Chrysler-Huntsville has also taken one of its contracting techniques from aerospace days and applied it to automotive electronics. Every project, no matter what size, has a production engineer assigned to it from start to finish, similar to the project-manager idea used in Government contracting. About 10 of these managers, called product leaders, keep tabs on cost, design, manufacture, test, and production efficiency from the time the project is identified (bid) until it's phased out of production at the end of its life cycle.



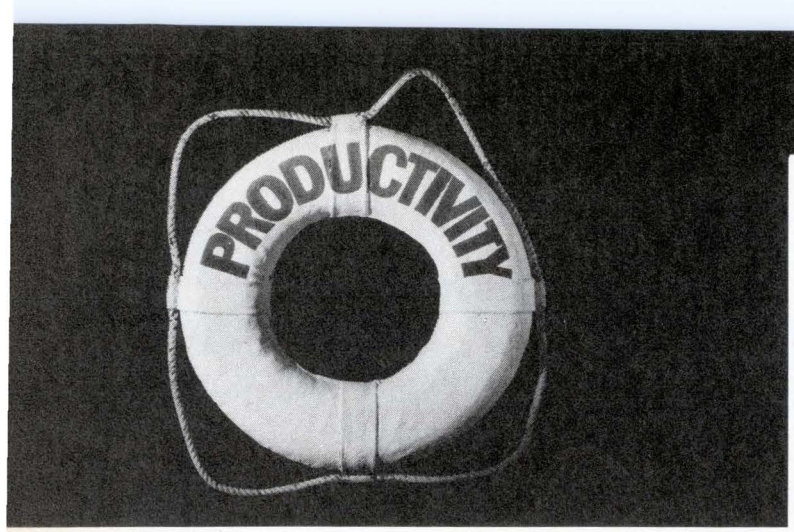
Homey atmosphere. To boost efficiency in hand operations, as in this Swedish plant run by Philips, workers have been given more leeway in deciding their hours, their work pace, and surroundings.

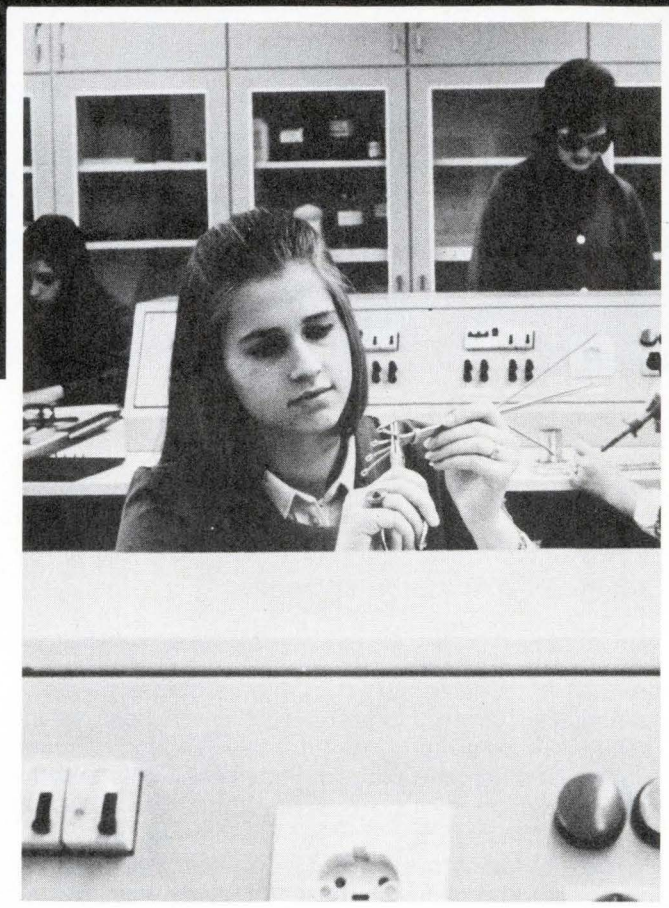
Along with the pay-point system and the product leader, Chrysler-Huntsville emphasizes communications with assembly workers. "We're fortunate here to have people who have worked on high-reliability space programs," says M. F. DeMaioribus, manager operations department. "These people know what they're doing, it's a matter of listening to their ideas."

Sharing the wealth, large and small

IBM Corp., noted for its paternalistic attitude toward employees, is one of the leaders as far as motivation is concerned, particularly in rewarding good ideas. Ray F. Boedecker, vice president of manufacturing, IBM System Products division, reports: "Our people at all levels are encouraged to keep their eyes open for cost-reduction opportunities and 'the better way.' There's always a better way. We count heavily on our resourcefulness and creativity to find it. Also, cost control is vital to increased productivity and profitability. The message is clear. 'Working smarter' is becoming an increasingly visible element in our business fabric."

IBM's suggestion program, for example, started in 1928 and now receives about 100,000 suggestions a year. Last year, IBM awarded $2.2 million for 17,000 suggestions adopted. Roughly 60% of the suggestions are manufacturing and laboratory oriented, while the





Learning. Training, too, has changed to improve workers' attitudes. Here a worker at Siemens learns soldering in a pleasant setting.

rest come from field and headquarters locations. Awards, which range from $25 to $75,000, are based on an estimate of time and materials saved during the first year of the suggestion's adoption. The author of the suggestion is paid 20% of the first year's savings, less implementation costs.

For a small company, like Brandenburg Ltd. in Great Britain, one of the best means of motivation seems to be a deliberate policy of employee participation and rewards. Brandenburg is a highly specialized instrument company that makes, among other things, a range of nuclear measurement gear, power supplies, and rate meters. It also makes high-voltage power supplies, high-tension transformer assemblies, and an "electronics fly killer" manufactured for Rentokil Ltd.

The various motivation devices at Brandenburg have included a design contest to solve the problem of fabricating the grid of the two-foot-long electronic fly killer. A two-person team won about $70 plus 50% of the direct cost savings for the first six months, which could amount to another $500. The contest was open to all employees, and a tool maker in the shop and the chief buyer ended up sharing the prize. The buyer had suggested using a special ceramic material, while the tool maker came up with a new design. Their efforts will save Brandenburg about 58 cents for each grid on a production run that could reach 9,000 units a year.

Brandenburg has a bonus scheme, too, in which 10% of increased turnover in quarterly sales above a certain quota is shared among the employees. It's handled on a point system on the basis of work or time completed each month. Now in effect for about six months, the plan has so far been worth about 22% above the average paycheck during the first three months.

Brandenberg, incidently, also holds periodic meetings of design engineers and production employees to kick around problems and gripes about a particular product. Employees are encouraged to suggest design changes that might improve production or lower costs or both. In one case an employee noticed that the company was purchasing metal clamps to hold a power supply in one of its products. At the employee's suggestion, the clamp was replaced at less expense by a molded fastener produced in-house.

An incentive system at Cherry Electrical Products Corp., Waukegan, Ill. has proved even more lucrative for certain employees. Each worker is assigned an allotment, fixed according to the person's position on the production line. When a worker exceeds the alloted amount, he or she receives a cash bonus as a percentage of base pay.

Before the economy softened the average bonus rate was running about 27%. Then, like many manufacturers, Cherry Electrical was forced to lay off some production workers, while retaining its most productive senior people. As a result the average bonus rate has increased to 42%.

Another company that believes in motivation by sharing the wealth is TEC Inc., Tucson, Ariz., a manufacturer of data terminals. TEC has a program called EARN—employee allocation of revenues now. Now is the key word. After-tax profits are calculated each month and each employee, depending on his monthly performance, receives a minimum award of 5% of his basic salary. The program was begun in July 1974, a time when many companies were giving across-the-board cost-of-living raises. Rather than going along, TEC established EARN with its 5% minimum "raise." But employees can and do get more than 5% each month, according to Hugh B. Reed, assistant to the executive vice president. And it has worked, says Reed. Last spring, the company was producing between 175 and 200 units per month. Now, TEC is turn-



Motivating managers. At Siemens' modern management training center, company brass discuss ways of improving their own productivity. The company spent around $130 million last year for in-house training and education, about 4% of total wages.

ing out more than 300 units per month with the same number of people.

In the avionics field, particularly, there is a constant effort to motivate people with "team" efforts, feedback from the field and seminars. At Bendix's Navigation and Control division each contract (DC-10, S-3A,) has its own production team with a foreman, inspectors, board tester, system testers etc. The foreman receives field reports and passes the information to his team. The team is thus kept up to date on the operating status of their job. The purpose of this system, frankly, is to "raise the spirit of the employees," the company explains.

At Controlation employees again are told what's happening in the field and are encouraged to go to seminars on the operation and circuitry of the equipment they are building. So far this program has resulted in several cases of upgrading in job function. Gull Airborne uses periodic employee meetings to motivate its production force. These meetings are used to discuss any problems relating to work flow.

And at AIL "quality performance charts" are posted in each department to let manufacturing personnel see the overall quality of their operation. The charts show each areas' weekly average of defects spread over 15 weeks. The charts also show the top ten defects at any particular station. At the end of each quarter two "Quality Improvement Awards" one for shop and one for electrical assembly are awarded to the most improved area. Major improvements as a result of this program were: 44% reduction in hand soldering defects; 36% reduction in part installation defects; 49% reduction in pcb defects; 25% overall improvement in electrical assembly.

In adding up what it takes to improve motivation, some companies go farther afield than others. But the results usually contribute to efficiency and cost savings, even if they are not directly tied to production.

Motivation Swedish style

While it's true that employee-motivation programs around the world have become more "democratic," employee relations at companies in Sweden are still considered in the vanguard. Its workers are among the highest paid in the world. Moreover, government employment regulations and social programs in which companies must participate would probably stagger most American managers. How, then, do Swedish electronics companies stay competitive? Once again the answer seems to lie in productivity improvements closely tied to worker participation. At Philips Industrielektronik AB (PIAB), a plant of about 100 workers making test instruments, the pay is about $4.50 an hour. The company has to figure an additional 25% for various benefits and employer contributions to insurance plans. The company also has to be ready to meet



demands by unions—and Parliament, too—for greater worker influence over their jobs.

Such moves range from having worker representatives on the board of directors, to the introduction of "flex time," which means that workers arrive and leave the job as they desire, within a 45-minute period. More important from a productivity point of view, workers are influencing the way plants are designed. Industrielektronik and other Swedish Philips production divisions will move into a new building outside Stockholm next year, and many of the layout details are being worked out by committees involving management, production workers, and union representatives. And under recent Swedish legislation, the plant's shop stewards are the ones who approve the health and safety features of the new facility.

All Swedish companies have worker-management councils for exchanges of information on policies, plans, and problems. The councils are used to elicit workers' ideas as well. On a more detailed level, PIAB keeps a graph on a central bulletin board showing the plant's output for the month, as well as details on material in stock and work in progress.

By the same token, Industrielektronik expects every individual on the assembly line to be more productive because of this participation. Says Wim Hazenberg, production manager, "We like workers to know they're responsible for their work. A person who assembles a pc board should know what's really important and not so important for quality. Otherwise, we have failed in giving instructions."

For today's worker, today's training

Training programs, too, have undergone changes, going beyond merely conveying instructions to become a part of employee motivation. In a sense, automation has raised the need for better-trained employees, even though there may be fewer on the payroll.

Thus, for example, even though the Siemens AG semiconductor factory in Munich, West Germany, spends more than a third of its capital investments for streamlining manufacturing operations. "The potentials of automation are limited," manager Dieter Roess observes. "Flexibility is getting smaller, and so is the margin within which automation brings added benefits."

So it's no surprise that Siemens is putting much emphasis on education of employees—and the intensity with which it is stressed "makes our company unique in West Germany's electrical/electronics industry," Roess asserts. The figures reveal that Siemens spent around $130 million last year for in-house training and education, an amount corresponding to roughly 4% of the company's outlay for wages. In certain specialized fields, Siemens spends up to $10,000 a person for training.

Particularly important in the management-education side is the $8 million training center at Feldafing, near Munich. Here strictly Siemens-related management courses, including ways of raising productivity, are covered at a rate of between 10,000 and 12,000 participant-days per year.

Referring to the investment in training, Roess states, "It's hard to gauge just how much all this contributes to high productivity, but we believe it has a decided effect."

Opening new lines of communications to workers, rather than simply outlining tasks and explaining an individual job, was part of an all-out effort to increase productivity at capacitor maker Vitramon, Inc., Bridgeport, Conn. Starting a year and a half ago, the company has made certain that every worker is kept up to date on all aspects of company affairs, not just put through on-the-job training.

Summarizing what many companies have learned in motivating employees, John Hatfield, vice president and general manager, says, "The new generation of workers will not do something simply because it's told to. They want to know why they are doing something, and what the result will be." □

Matsushita plays it again

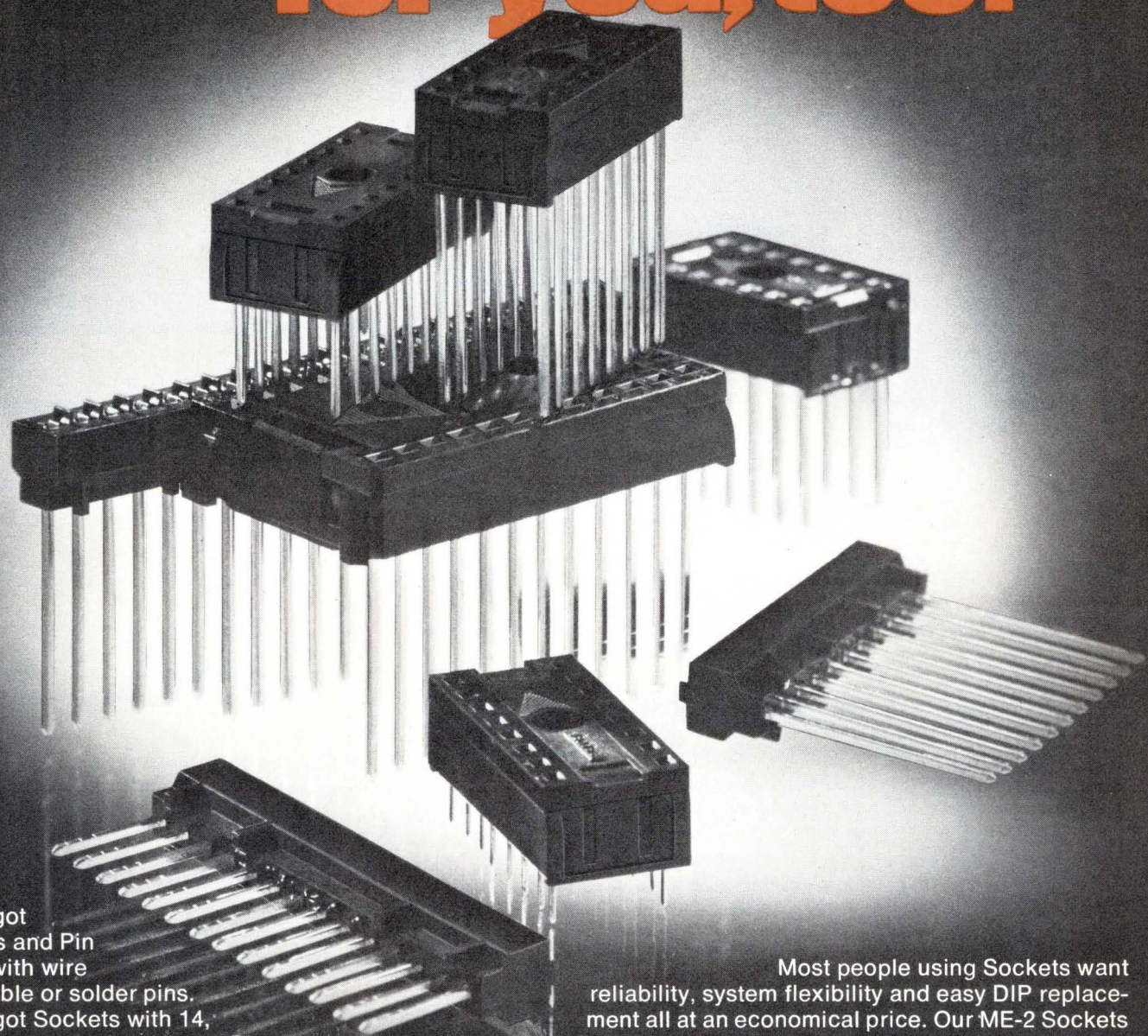
A custom still going strong in Japan is the practice of singing the company song, an idea that went out of style in the United States with the conformist '50s.

Fact is, the Japanese like to sing. So Matsushita Electric, for one, has always had a song, and one that was changed recently to harmonize better with today's thinking.

The old lyrics, more in keeping with the go-go post-occupation-to-mid-'60's boom, spoke of "Sending goods to the people of the world, endlessly and continuously, like water gushing from a fountain." Productivity-minded, the old lyric stated, "Let's put our strength and mind together, doing our best to promote production," and it ended with "Grow, industry, grow, grow, grow!"

With new attitudes on the part of workers and management, and with oil-crisis economics stifling the "grow, grow, grow" admonition, the lyrics are a bit more personal. Matsushita workers now sing, "Let us bind together a world of blooming flowers and a verdant land in love, light, and a dream." Showing that Matsushita knows where its employees' heads are, the song ends with "Animating joy everywhere, a world of dedication, let us fulfill our hopes—shining hopes—of a radiant dawn with love, light, and a dream."

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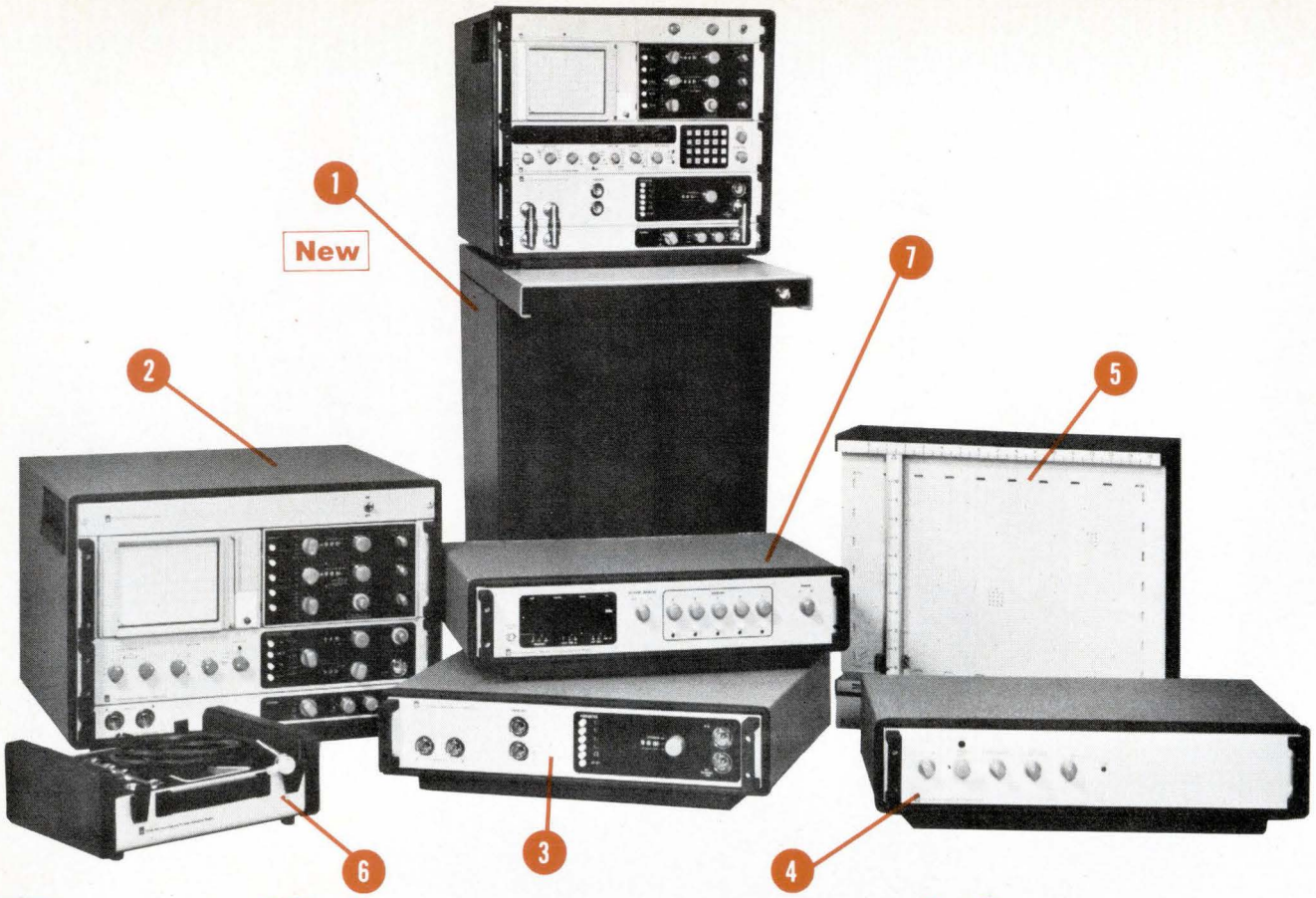
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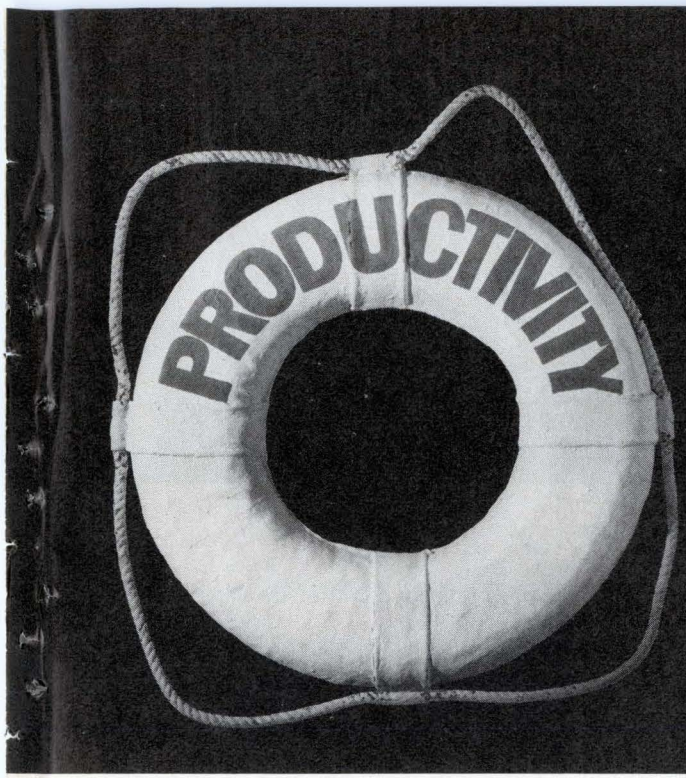
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Design plays vital role

Because of their technology base, electronics companies will increase their productivity and succeed in the international marketplace largely through strong design efforts

☐ For many electronics companies in today's world, "the drawing board is the key to survival," to quote one management consultant. Engineering has of course always contributed heavily to a company's productivity, but there's a new pressure on designers now, due to the increasingly international nature of the electronics markets and competition and to the rapid shifts worldwide in technological leadership.

Still, precisely because electronics manufacturing has such a heavily technological base, it has much to gain in the way of improved production efficiency from product design and redesign. The potential for improvement exists everywhere—in the manufacture of components, subassemblies, instruments, and computer systems. It exists particularly strongly in the preparation of software, which is becoming ever more of a problem now that programable devices are being used in so many new electronics products.

In some firms, design teams, departments, or even the entire company may be specifically organized to bear down on production, testing, and materials costs simultaneously with end-product performance. Finally, in a burst of self-examination, the design effort can also streamline itself by turning over the routine parts of the job to a computer.

Making components more efficiently

More and more products in the components sector of the electronics industries are conceived with eventual highly mechanized assembly in mind. "Unless you design a product at the outset for mechanization, it's not going to be a success," warns Stanley J. Kukawka, vice president and general manager of the electronics



division of Allen-Bradley Corp., Milwaukee, Wis.

But products are constantly also being redesigned to reduce their parts count (and thus simplify assembly); to extract the same performance from looser specifications that will boost manufacturing yields; to make the production process easier to automate; to adapt products to automatic testing, or to increase reliability (and so again boost production yields). The resulting improvement in output per man hour often cuts costs to such an extent that the manufacturer can pass some of his savings on to his customers—he may either cut prices or be able to hold prices firm despite rising materials and labor costs.

Companies like Allen-Bradley, Beckman Instruments, Bourns, Cherry Electrical, Liquid Xtal Displays, and Intermetall all offer examples of the use of one or more of these approaches:

■ A component competing in a mature market demands a high level of automation at the outset—for instance, the type CC precision metal-film resistor introduced last year by Allen-Bradley. "We knew the size of the market, we knew what share of market we could expect to get, we knew the selling price, and we knew what costs we had to achieve to get the gross margins we wanted. That justified our initial mechanization of the part, as well as our entry into the market," Kukawka explains. The resistor doesn't need end caps, so assembly steps are fewer, and wide manufacturing tolerance result in high yields.

■ The number of process steps is halved in a line of thin-film resistor networks that Allen-Bradley has just finished redesigning into dual in-line packages. The goals were to mechanize production and to profit from the rapid growth of the DIP market. To be launched this spring, each DIP contains a network deposited on a ceramic substrate that is then sandwiched between screened overcoats.

However, halving the process steps meant the production work flow had to be revised. Of the nine machines involved, the first takes materials loaded in bulk, the last puts finished products into shipping containers, and those in between have common inputs and outputs, like magazine loaders for maintaining device alignment from machine to machine. This equipment is arranged in a meaningful flow—that is, workers can easily associate the successive manufacturing steps with successive work stations, so that training time in starting up the line is reduced.

■ Ease of automation and simplified assembly were also goals when Beckman Instruments Inc., Fullerton, Calif., adopted two new pin-mounting methods for its cermet trimmers. Being replaced was a process of firing in pins that was hard to automate and for different pin arrangements required different substrates (which contain the resistive element).

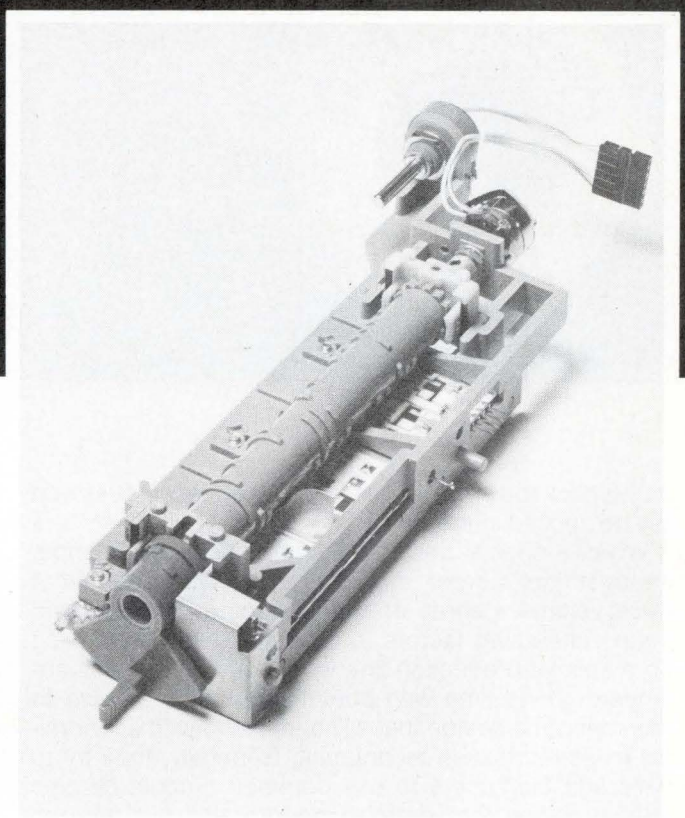
For its model 72 and model 89 plastic cermet trimmers, Beckman now uses clip-type terminations—to make them, the substrate is simply slid into a pressure clip, and the same substrates can be used for different pin arrangements by just changing the clip design. Further, a solder-coated spring material is all that's necessary for the clips, whereas fired-in pins must be of precious metal. Altogether, cost savings of 30% to 50% were realized.

For its model 91 unsealed ⅜-in. cermet trimmers, Beckman now uses swaging—the pin wires are simply hammered into mounting holes. The process is less expensive than pin firing and, like the clips, can easily be automated when necessary. Again, the trimmer substrate need not be changed for the 12 different pin arrangements, which Beckman obtains simply by bending the protruding wires at different angles.

■ A reduced parts count and a change of material simplify assembly of Bourns Inc.'s model 3006 and 3009 ¾-in. rectangular cermet trimmers. Previously, the shaft was held in place by a retainer, and the unit was sealed by an O-ring. Two years ago, though, the Riverside, Calif., company changed the body material from a hard, rigid, thermoset plastic to a thermoplastic, which is easier to mold and more flexible. This change enabled Bourns engineers to design a shaft that can be mounted simply by being pressed into the trimmer body. A reliable seal is formed as the flexible plastic closes around the shaft.

Incidentally, Bourns, like Beckman, has switched to swaged terminations for its cermet trimmers.

■ Substantial assembly and material cost-savings were realized when Cherry Electrical Products Corp. of Waukegan, Ill., switched from riveting to ultrasonically welding assemblies for its series E33 miniature snap-action switches. The welded units are also more rugged and reliable—a good illustration of president Walter



To spec. By designing this attenuator to halve the parts count and save production labor, Tektronix was able to cut 50% off its cost. This subassembly is used in the model 455 oscilloscope.

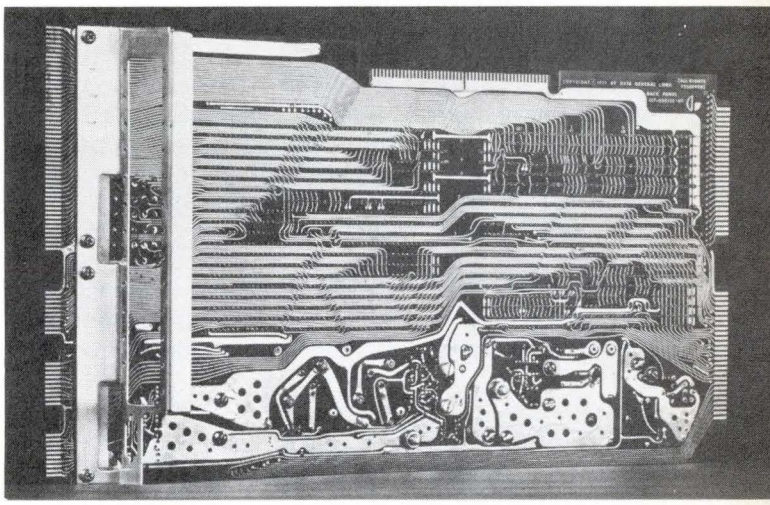
Cherry's philosophy that the effort of redesign is not worth it unless it improves the product as well as lowering material and/or production costs. Simply extending automation (which he's doing) is just not enough, Cherry says. Under the firm's ongoing redesign program, many products have been reworked to offset escalating costs of labor and materials.

■ Improved reliability both increased production yields and reduced prices when Liquid Xtal Displays Inc., Cleveland, Ohio, redesigned its displays—basically liquid crystals sandwiched between a glass frontplane containing the segment pattern and a glass backplane containing the conductive common pattern. Since the terminating connections for the display are usually located in the frontplane, crossovers are needed between the backplane and frontplane.

Liquid Xtal originally made its displays with separate backplanes for each digit and a single crossover for each backplane; but if one of these crossovers opened, the display would not operate properly. Now, however, the company is using a single common backplane for each display, with redundant (two or more) crossovers from the backplane to the frontplane. This redesign boosted production yields by about 20%, and the company was able to cut its prices by 10% to 15%.

Because the conductive patterns of these displays were long and narrow and only about several hundred angstroms thick, they were highly susceptible to opens during production. To counter this problem Liquid Xtal developed a dual in-line form that is currently being used for all of its watch displays. The DIP display has termination connections on two sides, not just one, so that the conductive patterns can be short and wide, making them half as susceptible to opens as the long, narrow conductors. With this change the company improved its production yields by another 20% and reduced prices again by additional 10% to 15%.

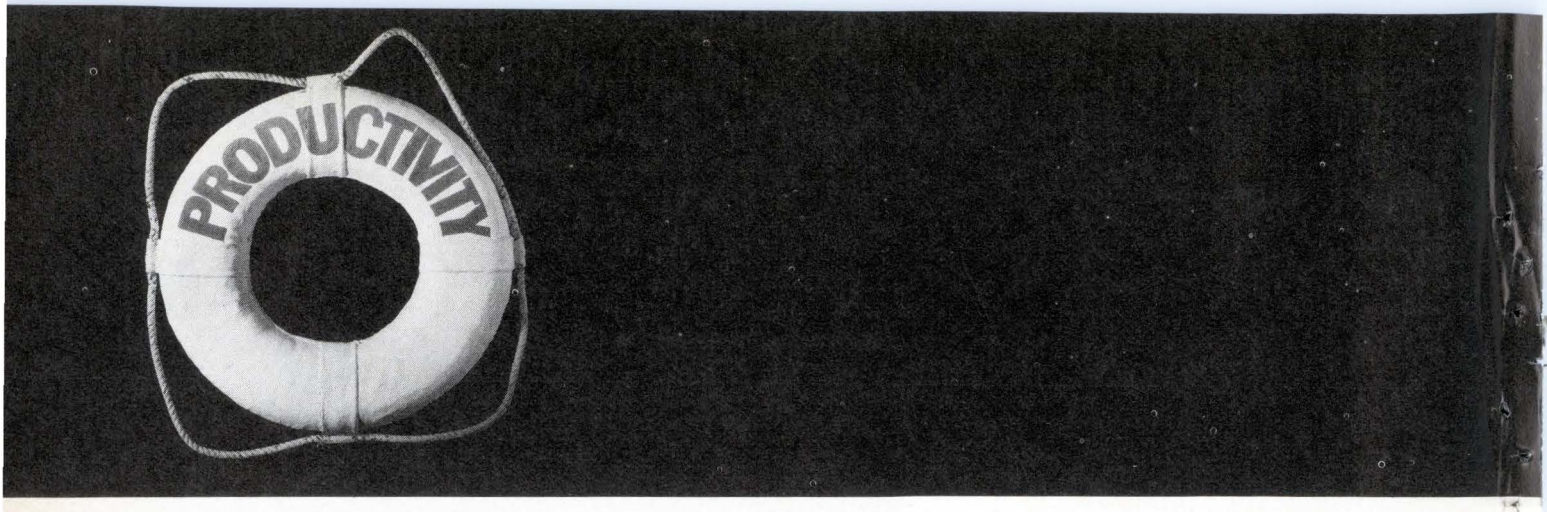
■ Sometimes a component may have to be redesigned to suit more streamlined testing processes. For instance, a zener diode made by Intermetall GmbH, the ITT Semiconductor Group in Germany, had to be adapted to new high-speed testing equipment. To do so, Intermetall replaced the copper leads with axially arranged leads made of a ferromagnetic metal. This material makes it possible to suspend the components magnetically for fast handling during automatic testing.



Engineered efficiency. When Data General put integrated power-supply circuitry into the backpanel on three Nova computers, backpanel wirewrapping was eliminated as well as much hand wiring.

Because no mechanical contact is made with the devices, the leads are also protected from being bent or damaged during handling.

■ Output per man hour can even be boosted in producing custom-designed integrated circuits, a market that accounts for a rather large share of Intermetall's business. Most special designs, according to plant manager Horst Knau, affect the circuit layout on the integrated-circuit chip rather than the lead configuration



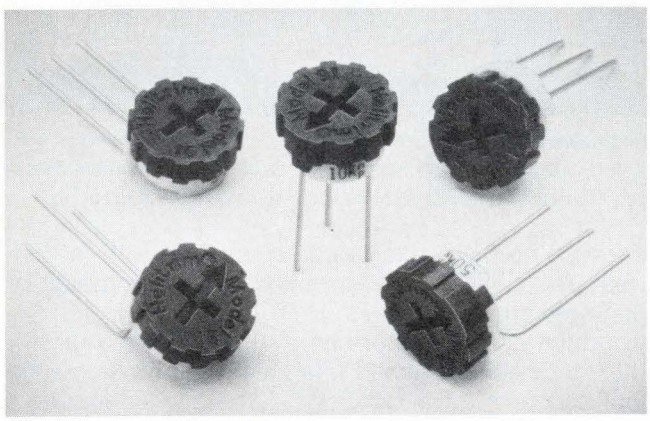
or the package. Thus, mass-production techniques can still be applied in these two areas.

When a special design calls for a package change, the customer's order is carefully evaluated in terms of sales volume, degree of manufacturing difficulty, and other scheduling factors to determine whether setting up a special production line would pay. Intermetall engineers spend time with potential customers trying to hammer out a design that will best blend with economical mass-fabrication techniques. Generally, they try to persuade customers to use common pinouts or chip configurations that promise good yields but perform the function desired. As product manager, Ruediger Karnatski, puts it, "Productivity starts right at the customer, though engineers should never lose sight of what the customer wants to achieve."

Trimming TV assembly costs

Consumer-product companies have become masters of the art of designing pennies out of the cost of products. Television-set manufacturers are perhaps among the most sophisticated, and they focus on productivity improvements at the subassembly level.

In recent years they have introduced a modular chassis, which not only makes printed-circuit-board modules practical, but reduces chassis assembly and testing steps. Even consumers now understand that "works in a drawer" modularity, first popularized as a slogan by Quazar Electronics, Chicago (formerly Motorola Consumer Products division), means easier and cheaper maintenance, hopefully extending this productivity improvement to the repairman.



Pin money. By swaging instead of firing in the pins on these trimmers, Beckman Instruments makes manufacture easy to automate. Also, bending pins produces 12 different pin configurations.

The in-line self-convergence TV picture-tube developed independently by RCA, Philips, and Toshiba is another subassembly that reduces TV-set assembly time. Since the convergence and purity are independent of the driving circuit on these tubes, the yoke and neck components can be set up, adjusted, and permanently attached at the tube-manufacturing plant, eliminating several production steps for the set maker. In addition, the CRT requires fewer dynamic tolerance compensation circuits than delta-type picture tubes, another major savings in production cost.

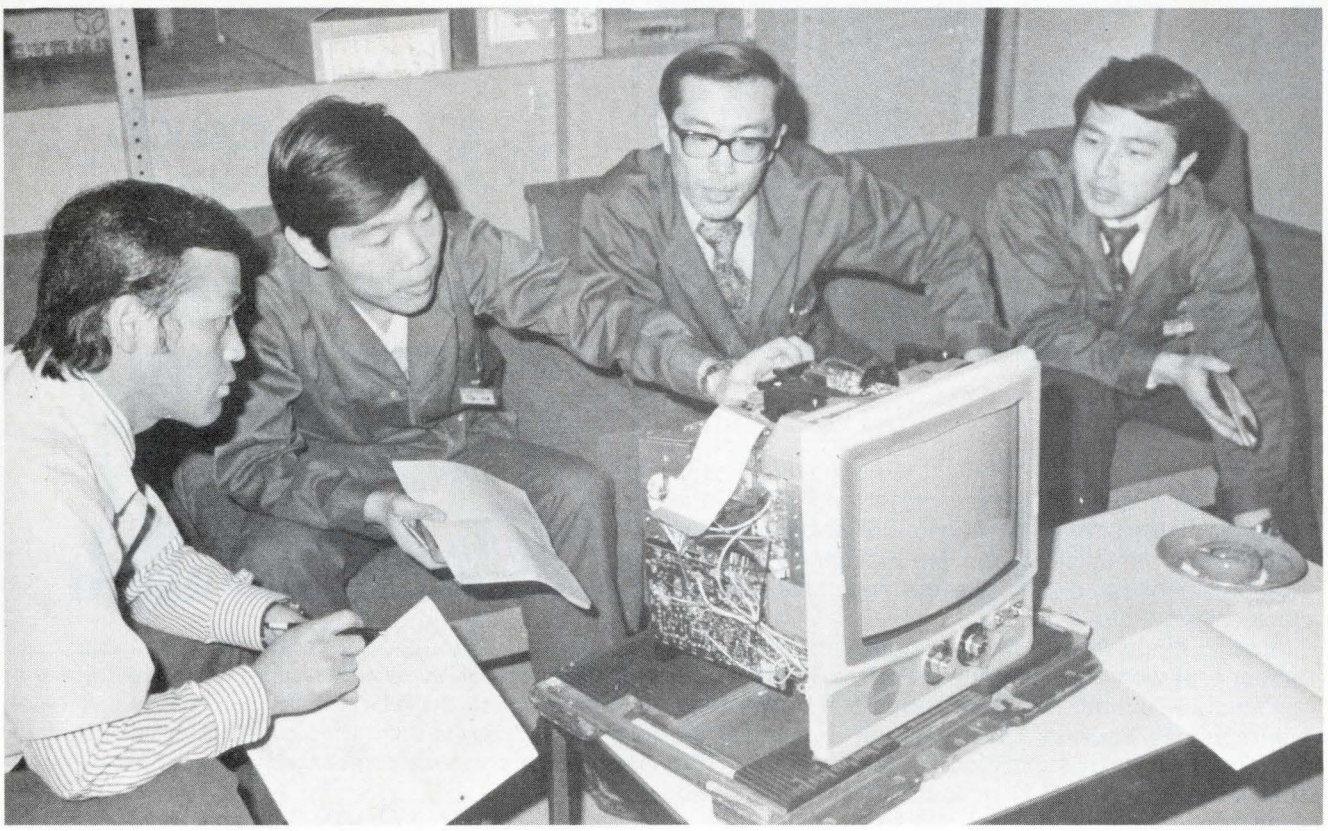
Along similar lines, Grundig in Germany has begun to use p-i-n diodes in its solid-state TV tuner. The diodes feed uniform and steady signals to the input transistors of the subsequent vhf and uhf stages. This arrangement eliminates the need for workers to adjust these frequency stages, and it also allows the use of high-current input transistors. As a result, p-i-n diodes not only improve tuning performance, they also reduce manufacturing and testing time.

Much attention has been given to reducing the mechanical complexity of radios by Matsushita Electric's radio operation in Japan. For example, the string drive for the tuner, while adaptable to different mechanical configurations, needs an inordinate number of tiny parts that can only be put together by hand. In some new radios, the string drive is therefore being replaced with an inexpensive plastic worm-gear drive that is assembled swiftly by operators using machines.

To simplify assembly, Matsushita has also redesigned radio cabinets. In a clock radio recently introduced, the clock, speaker, power supply, and chassis are all dropped into slots in the cabinet and held in place with the back plate. In a conventional design, each of these subassemblies would be fastened separately to the cabinet with screws or other fasteners.

Streamlining low-volume lines

While designing for automation is a must in the high-volume TV-set lines, redesigning to reduce assembly time can also benefit low-volume products. Sometimes it can be done by making a precise determination of



Team efforts. Many companies have formed engineering teams to redesign products for lower-cost production or to shoot for a precise market price. Some teams, like this group at Sony analyzing a TV set, are able to reduce assembly steps by eliminating circuits.

exactly what is functionally required and then redesigning completely to deliver that function more simply. In other cases, the intelligent use of software may help.

Parts count was reduced, for example, with the Tektronix model 455 oscilloscope [*Electronics*, March 20, p. 139]. Specifically, the Beaverton, Ore., firm was examining possible cost improvements in the design of the input attenuator, the precision variable divider which controls the vertical deflection setting.

For the model 455, the attenuator called for an input sensitivity range of 5 millivolts to 5 volts per division over a 50-megahertz passband. One possibility was to adapt the higher-performance attenuators designed for the large-bandwidth scopes in the line, models 465 and 475. But this would have cost too much.

The goal was to cut the 455 attenuator cost in half, and this was achieved by a number of design steps. Most important was a reduction in parts count through the use of molded plastic resin parts wherever possible. Bearings were molded into single pieces which snap-fit into the frame. Even the front-panel control knob was fabricated as a snap-in part. Also, thick-film networks deposited directly on a ceramic board were used instead of separate hybrids mounted on a conventional printed-circuit board. The final parts count achieved is about half that of the more expensive 465 and 475 attenuators.

In addition, fewer calibration adjustments are needed for the 455 attenuator because of the use of laser-trimmed thick-film resistors. All told, these design ideas accomplished a better-than-50% cost reduction, mainly by enabling labor savings in production.

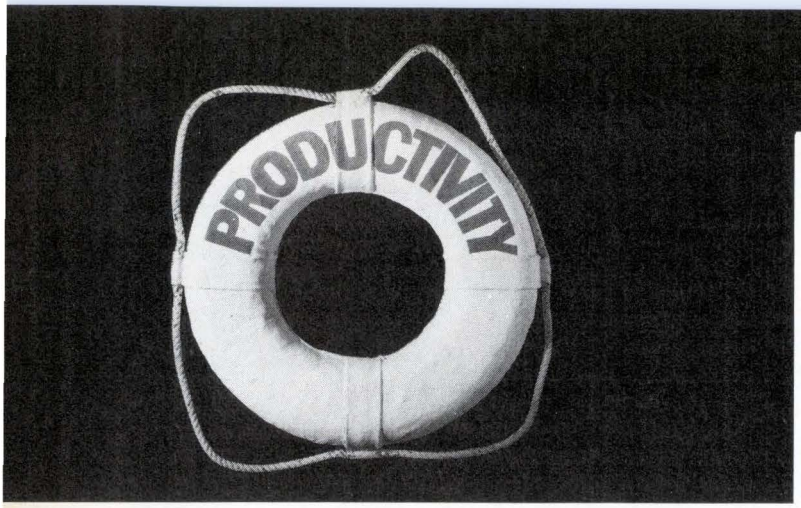
A software approach is used at Prime Computer Inc. of Framingham, Mass. (see also "Software is harder," p. 129). The minicomputer maker finds that its extensive use of microprograming increases productivity and also makes product redesign much easier. For example, the company builds a standard peripheral controller that can be used with many different peripherals when equipped with the appropriate microprogram. But instead of a board's being changed, only the microcode need be changed, so that many problems on the factory floor are eliminated.

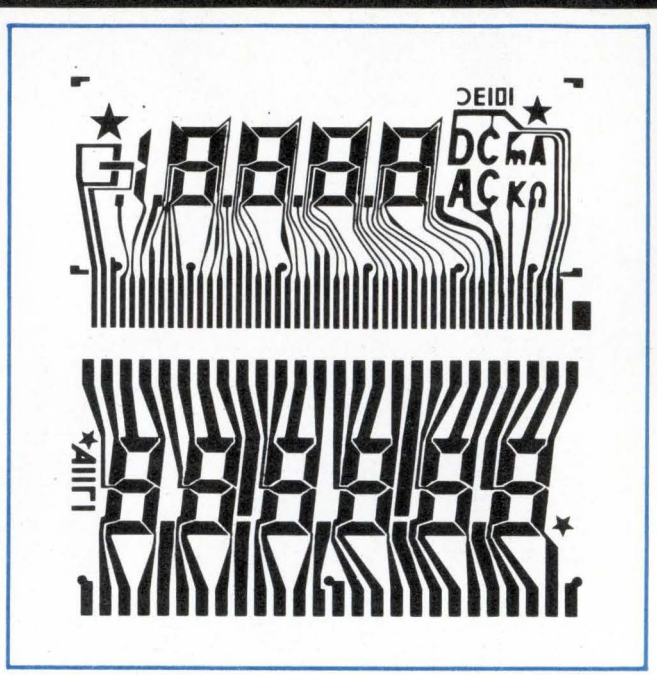
Organizing for productivity

A few companies deliberately organize themselves to design products that meet an exact cost goal or to optimize the interface between design engineering and production. The payoff can be impressive, as Texas Instruments' experience shows.

TI calls this type of effort Design to Cost. Though cost normally is an important design parameter, the Design to Cost program institutionalized the idea by making it a basic responsibility of engineering.

First step in the program is to set a market price that will pay a profit and to target costs to come in under that figure. The next step is to put a design team on the task of coming up with minimum performance and function specifications. Costs and technical integrity are audited at intervals by experts from engineering,





Thicker and better. Sometimes a redesign improves productivity by improving reliability. For instance, when Liquid Xtal changed the design of this display to permit conductive patterns to be short and thick, conductors no longer opened and yields went up.

who also insure that the product is on schedule.

"Total product dollar goals are not negotiable, and that's the hardest thing to put into the heads of design engineers," remarks Joseph D. Zimmerman, group vice president for digital systems and materials and electrical products.

A good example of how the TI program works is a project that won the company a Federal Aviation Administration contract for the ASR-8 airport surveillance radar system. Back in 1970, General Dynamics had won the contract by submitting a price lower than TI's. But in February 1973, TI set out to win the business away from its competitor.

The Design to Cost team was highly motivated, says Zimmerman, by the fact that if it did not come up with a winner, the engineers would be out of jobs. They did have a couple of advantages, though—they had more freedom to change internal specifications for this FAA equipment than is usual on Government contracts, and they were also able to take about six months longer than usual in reaching the final design.

Going deep into the circuitry design, the team combined functions in the receiver section to cut out components and boards. The antenna manufacturing procedure was improved to save costs, and better algorithms were employed for the signal-processing section. In short, the team made across-the-board changes and tradeoffs to meet the price target.

In October 1974, TI won the contract by offering the FAA a better price just at the point when General Dynamics ran into trouble meeting deliveries. The redesign worked because each engineer had a product cost budget, Zimmerman concludes.

Meshing design with cost-effective production is a company-wide way of life at Modular Computer Systems Inc., Fort Lauderdale, Fla. "As opposed to changing designs to improve productivity, we influence design to help optimize productivity right from the beginning," says Richard Adams, manufacturing manager. "You've got to have the manufacturing development engineering people 'real tight in bed' with the development engineers way back in the design review and breadboard stages of new-product development."

Such cooperation is standard procedure for every product. In fact, it has been official company policy ever since Modcomp started about five years ago. The company founders, familiar with the walls that often build up between design and manufacturing, decided that they would not allow barriers to be erected.

What makes this policy all the more unusual is that practically every Modcomp product involves both hardware and software and has therefore been designed by a hardware-software team. "We don't operate like many companies where software is in one area and hardware is in another," says Joseph Godfrey, director of software development. "If we want to produce a new product, right from day one the hardware and software people start working on it together so we can get things put into the hardware that make the programing easy." Conversely, if elements start going into the hardware design that will make the software design difficult, Godfrey's people speak up and get them changed.

"It's not a looking-over-the-shoulder thing," Adams stresses, "it's a heavy interdepartmental cooperation with considerable give and take."

More time for creativity

Finally, what about the productivity of the design-review process itself? Here, the computer can maybe help, as Data General Corp. of Southboro, Mass., hopes to demonstrate.

The company's new system of computer-aided design reviews is intended to determine a product's performance while the design is still on paper. It allows the company to go from paper to a pc board and skip the breadboard stage. Vice president Carl Carman notes that "it is difficult to change the creative process, so we are changing the mechanical process of design to shorten the implementation period and leave more time for creating." However, he believes that it will be about

Software is harder

As if hardware redesign weren't enough trouble, computer manufacturers are facing the added burden of improving the rate of output of software designers. Software is as much a part of a computer system's costs as hardware, and, with hardware costs continually coming down, the extreme slowness with which software productivity improves is becoming more of a problem than ever.

Solutions being tried by different companies include: making a program a one-man effort or, where that's impossible, planning an organized team effort; avoiding low-level languages; and modularization of programs.

Software design, like other types of writing, is essentially a one-man effort in which success depends on the creativity of the designer. One problem, for example, is that it is often difficult for a second programer to pick up another's work. There are subtleties in a program that are often not apparent even with careful study. For instance, at Le Matériel Téléphonique, which produces electronic switching systems for the French telephone network, it takes about 50 to 80 programers working for one to two years to program one new exchange. And, if anyone leaves, says quality control manager Georges Borel, much time can be wasted as the replacement tries to pick up where the previous programer left off. The only way to combat this, he says, is to force all programers to completely document their work so that new programers can get a running start on understanding previous work.

As often as possible, minicomputer companies such as Modular Computer Systems Inc., Fort Lauderdale, Fla., are allowing one programer to follow a system completely through the various design, checkout, and debugging stages, rather than assigning such tasks to specialists in each area. Joseph Godfrey, Modcomp director of software development says, "More than half the software products are one-man efforts, from taking original customer specifications to releasing documents."

Modcomp also is designing its own high-level system programing language to allow programers to perform more efficiently without spending time on details, as is required when using lower-level assembly language. This is a pilot program now, Godfrey says, but "I'm hoping that we will be able to write a program at least twice as fast as we could with assembly language." Godfrey says that Modcomp also is attempting to modularize compiler designs to effect some standardization in the programs.

Compilers, he points out, have three main stages: syntax analysis, in which information from the user is converted to assembly language; optimization; and finally code generation, in which machine code is actually produced. "We feel that the optimization and the code-generation phases could become pretty standardized," Godfrey explains. "And if we can write front ends to those stages for the different compilers, we may be able to get many compilers available for a much cheaper price."

Prime Computer Inc., Framingham, Mass., also employs a high-level language on its own computers to develop programs. Prime's engineering vice president J. William Poduska claims that, by using Fortran in place of machine language, his programers produce seven to 15 times as much work. He notes that programing productivity could be related to attention span in one day, and a higher-level language puts about 10 times more information in front of a programer than does machine language. Also, according to Poduska, there is very little penalty associated with a high-level language: it takes more memory, but today, memory is comparatively far cheaper than a programer's time.

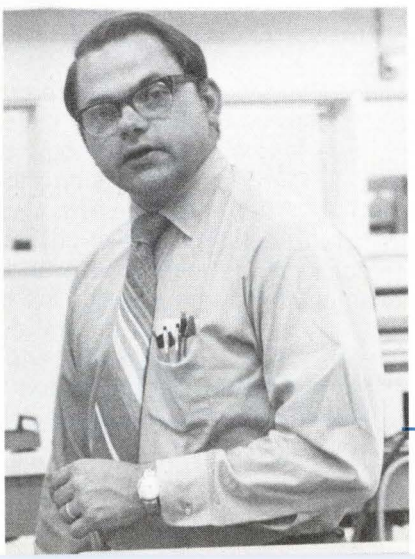
And Prime is flexible about its use of Fortran. Any parts of a Fortran program that take too much time are rewritten in machine language. The idea is to get the job done, and only then refine it where necessary.

Just as complete hardware testing improves productivity by cutting rework, completely debugged software can prevent many later problems. "The cost of finding and fixing a problem after the system is released can be as much as 30 times the cost of fixing it in unit test, the first set of tests our code goes through in development," observes Ted E. Climis, vice president, system development, IBM System Development division, "while the cost of fixing a problem during coding is almost nothing. Today our objective is to spend more money early so we spend less later and have a product with significantly fewer errors when we are through."

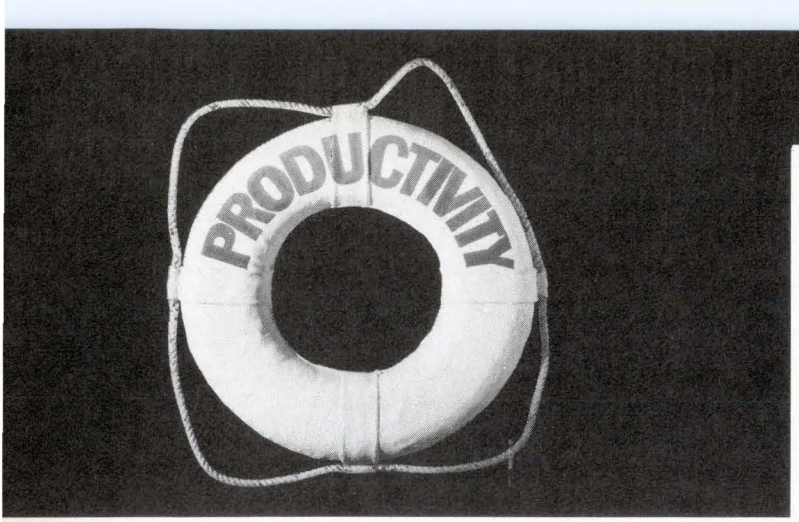
One of the key software-production innovations at IBM is the programing team, whose leader is responsible for preparing both the functional specification and all design, logic specifications, and all code. The programers on the team are responsible for initial design and code, their own detailed planning, and testing. A librarian, who completes the team, is responsible for creating and maintaining the library for the project, including both documentation and code.

Modular programs can also help software preparation, much as standard modular subassemblies have helped improve equipment production. At Interdata Inc., Oceanport, N.J., Edward Spuler, manager of software operations, says that many of his company's programs are now being packaged as "components" that fit into a major software package. Programers then need only specify the number of a particular package, and a computer will produce copies of the program on all the magnetic media used with the company's minicomputers. "This has greatly improved our throughput compared with the old method of manually copying one program after another," he says.

Interdata also is installing CRT terminals in the programing area and has dedicated a computer in the computation center to software production. With the terminals, software will be developed in an interactive mode, as opposed to the batch mode that is presently used at the company.



More. William J. Poduska, Prime Computer's engineering vice president, says programing output increases up to 10 times if Fortran replaces machine language.



Standardizing can aid productivity

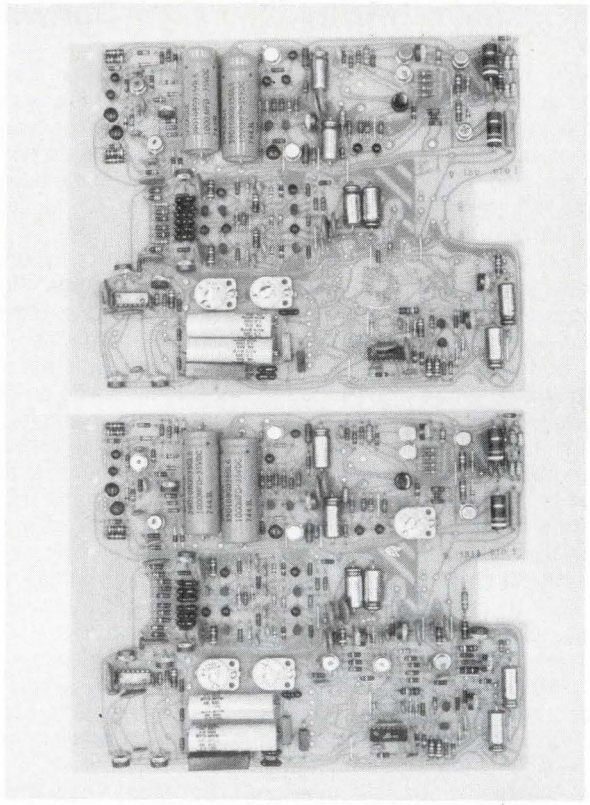
Besides providing cost benefits, a thorough-going standards program often simplifies product assembly. Fewer assembly lines are needed, the number of parts an assembly-line worker has to handle is reduced, and training periods are shortened, since many of the skills learned on one job will be directly applicable to the next. These advantages emerge in small-quantity production as well as in mass production.

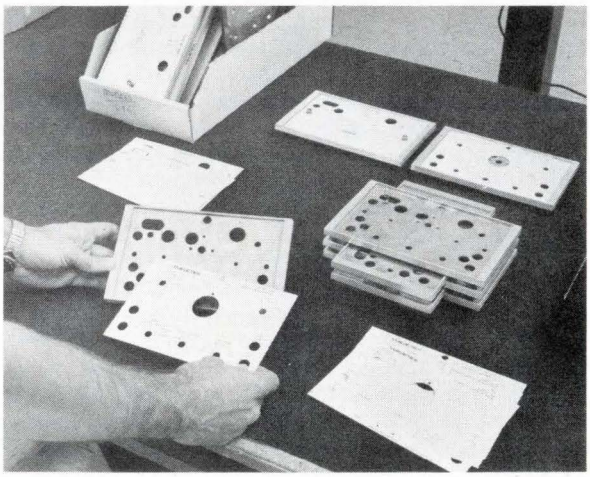
Wavetek, an instrument manufacturer in San Diego, Calif., is a good example. Standardization extends from packaging to printed-circuit boards to components, says Henry Reinecke, vice president engineering.

Like many other instrument firms, Wavetek uses the same basic cabinet for a wide range of products. But Wavetek goes a step further. With few exceptions, the cast-aluminum front and rear panels on its instruments are identical. Holes cast in the panel are located to handle various combinations of control positions as well as a line-cord connector, fuse holder, and other components. The panel becomes dedicated to one application only when an engraved plate, which covers unused holes, is added.

Wavetek often uses the same printed-circuit board for different models within a series, leaving out components that are not necessary in a given product. Various features available on different units within a series can be accommodated by adding the appropriate parts.

On occasion, though, standardization may work against productivity. For instance, Wavetek standardizes on components—it limits the number of resistor types it must support in inventory by using only 1% resistance tolerance devices and only a small number of resistance values. To obtain non-standard values, several resistors must then be connected in parallel or series.





Simpler inventory. Wavetek uses the same pc boards (top) and front and rear panels (bottom) for different models.

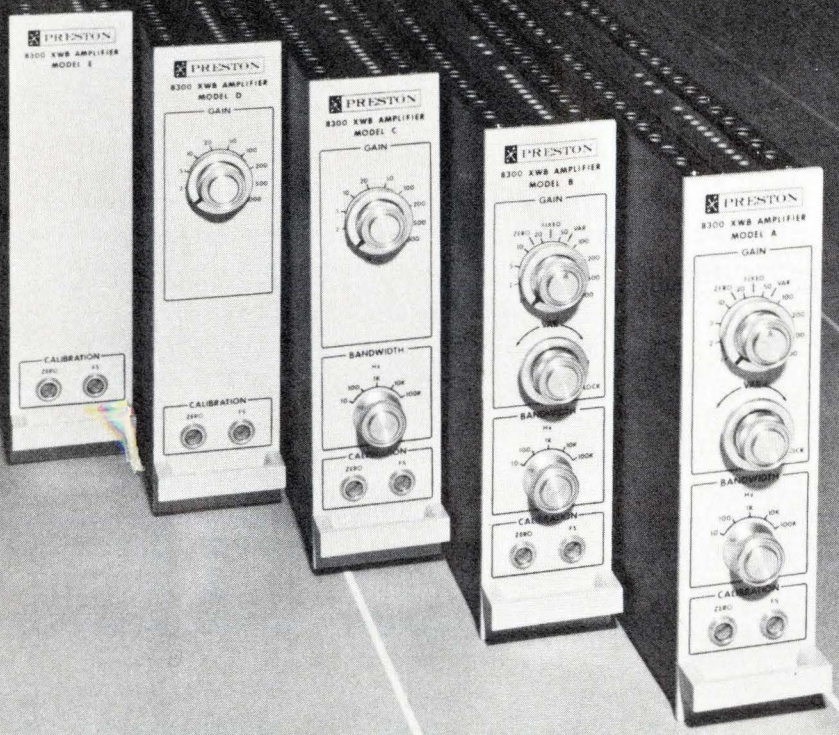
a year before Data General will be able to determine the efficiency of this computer-aided design review.

After a preliminary design is approved, the designer submits it to artwork. An automatic plotting machine produces a drawing, and the information is digitized. This information is used eventually as a data base to make parts lists, to punch tapes for manufacture of the boards, and to set automatic module placement for insertion machines.

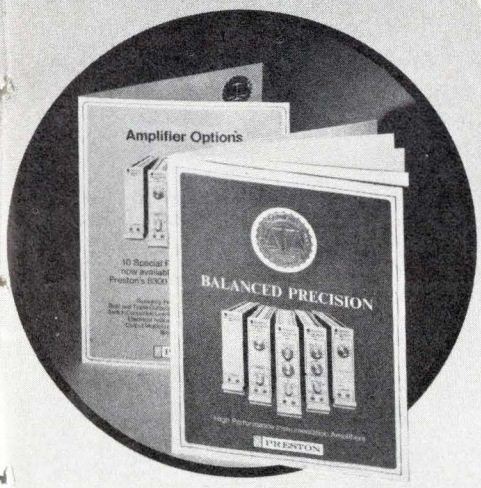
The original design is checked with the plotter's schematic and the data base to make sure routing and schematics match. Then, using the data base, a computer generates a program to test the simulated board. Eventually the system will have the ability to simulate tests on logic and put in test words. Carman notes, "Simulating allows the computer to do the ultimate design review."

The errors can be corrected in design review, saving about 30% of design time. After the designer corrects the errors, the board repeats its trip through the computer design review until everyone is satisfied that the board will perform as desired. The efficiency of these design reviews apparently depends a lot on whether the design is done with standard components. □

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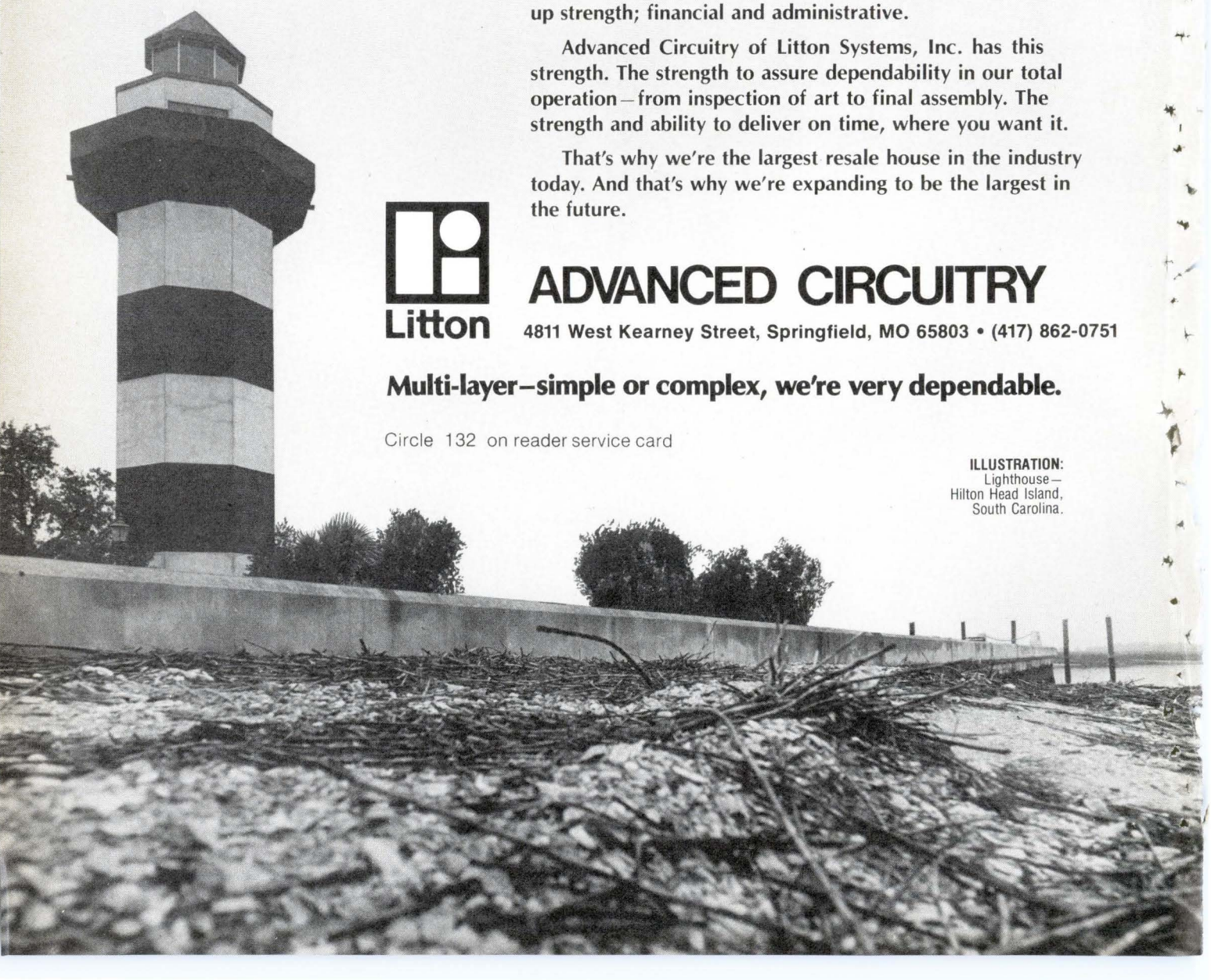
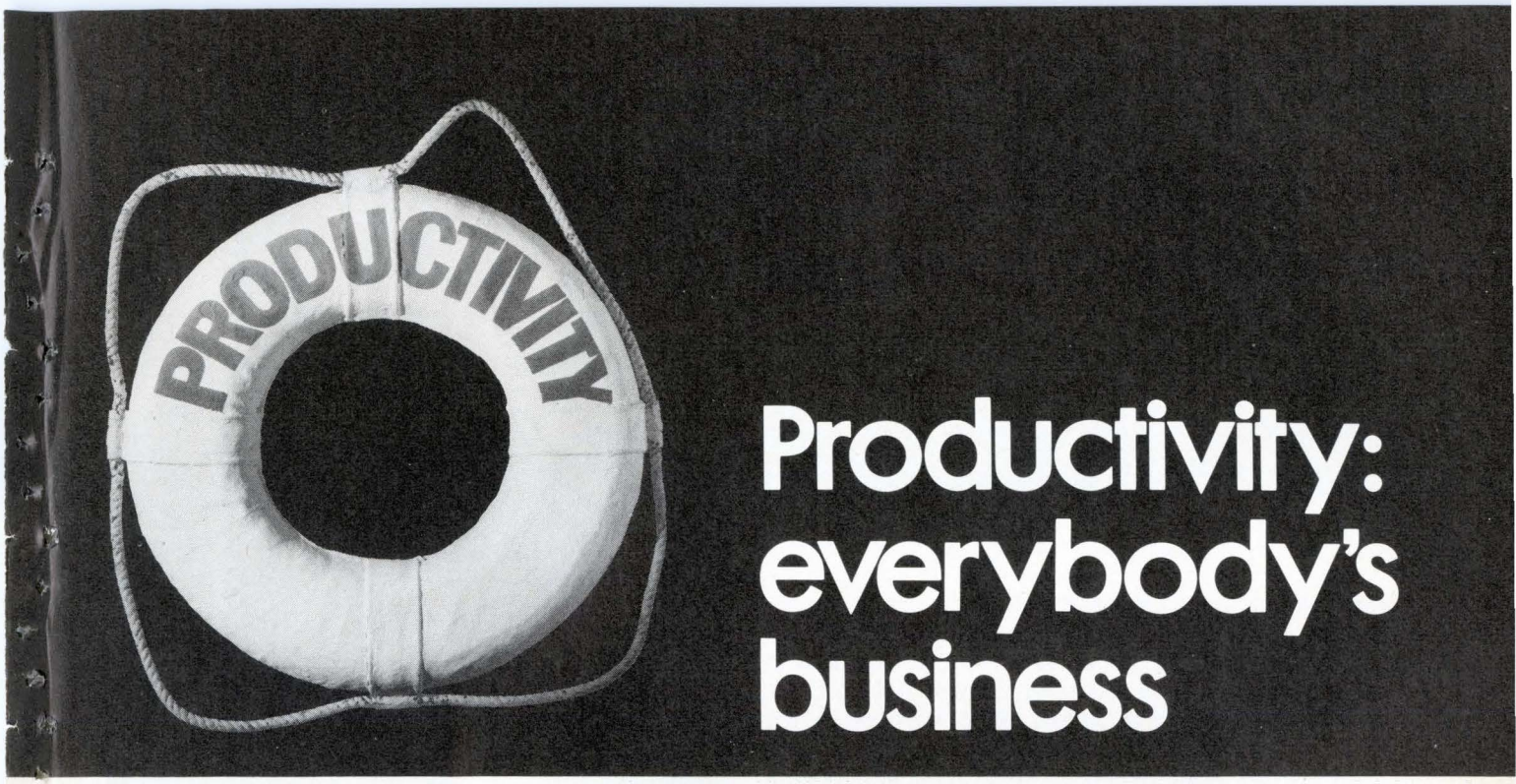


ILLUSTRATION:
Lighthouse—
Hilton Head Island,
South Carolina.



Productivity: everybody's business

Starting with management, other functions, such as accounting, purchasing, and sales, contribute to a firm's over-all productivity; distributors are streamlining operations, too

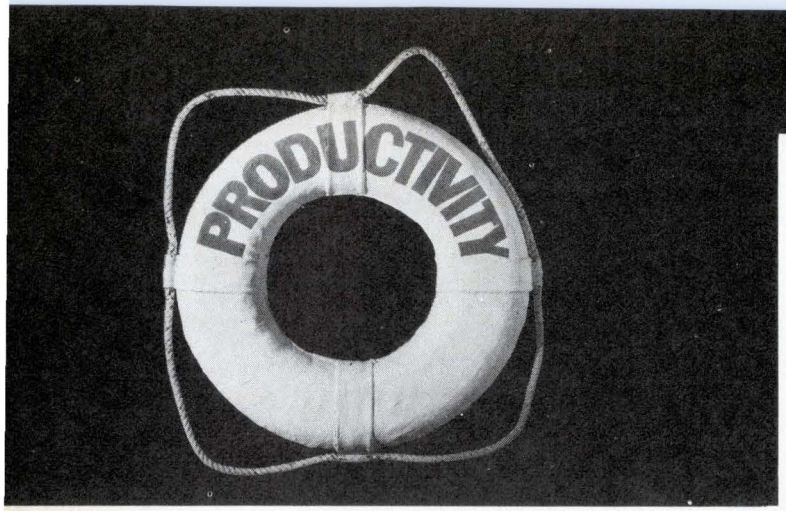
☐ Assembly lines are not manned by company presidents, accountants, salesmen, or purchasing agents. Nevertheless, these functions do affect a firm's over-all productivity. For ultimately, increased output per man hour must be translated into dollar volume of profit, that's what the nonmanufacturing personnel do, and that's what they can do more or less efficiently.

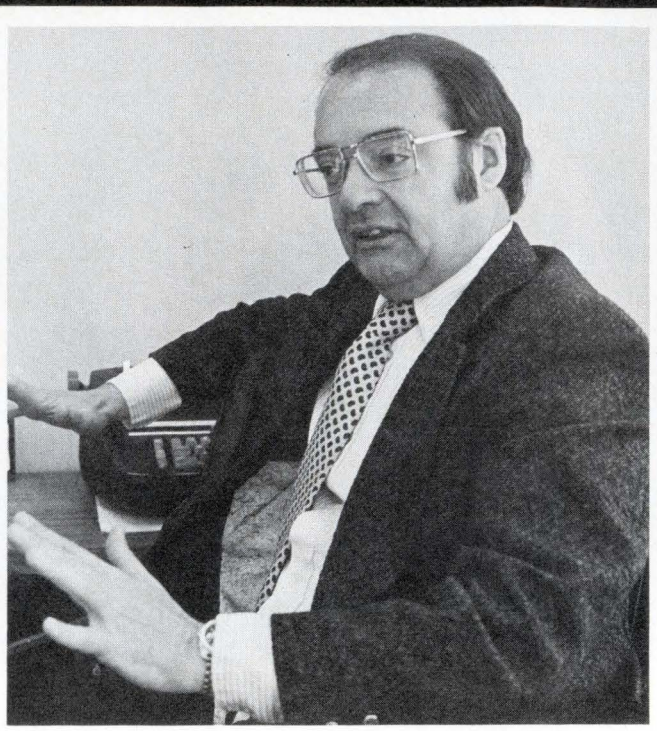
Their approaches are different. Accountants can provide cost analyses and track cash flow closely. Purchasing departments can refine the programing of their computerized inventory-control operations. Salesman and distributors can streamline their communications with the company. And within the company, top management is productive when it comes up with a strategy for improving the organization's productivity.

Top management's role in directing productivity improvement efforts has changed sharply in the last decade. As consultant Arnold Judson of Arthur D. Little Inc., Boston, points out, executives seeking to improve productivity must get rid of the notion that the results can be frozen in hard numbers.

"The trouble is that companies have been forced into a piecemeal approach," he notes. "They deal with measurable areas, while the most dramatic improvement may take place in areas that can't be measured."

Judson warns executives that productivity is not an individual nor small-group achievement, but must involve the total organization. Equally important, no strategy to improve it is good for more than four or five years. The key is always a change in behavior, and that cannot be commanded, says Judson, adding that the employee's wage today buys only an agreement to report for work and thereafter maintain "a minimal level





In management's court. Stressing that top management sets the pace of productivity improvement, TRW's Thomas Wickes advises that all departments can contribute, if communications are open.

of activity." One thing hasn't changed, Judson concludes, "The ball is still in management's court."

Agreeing that management sets the tone and pace in over-all productivity improvement, Thomas A. Wickes, a psychologist who was largely responsible for setting up a team-production concept at TRW Inc., says, "One of the things I never do is promise 'x' number of dollars or 'x' number of hours out of the team."

That concept, in which workers assemble a product as a team rather than in assembly-line fashion, has grown out of an effort begun by TRW in the early 1960s in which management and hourly workers share ideas and together push them through the production cycle.

"Take this case," explains Wickes, who is now director of employee relations at TRW's Automotive Worldwide division. "The top managers of a division were trying to decide whether to try to develop some new technology or merely adapt the old. The sales manager, a former engineer, had an idea that opened the door to a decision. It sounds simple, but in many traditional organizations, sales people are discouraged from thinking about anything other than sales."

Keeping a grip on costs

As essential as motivating company personnel is the job of making sure "you know where your costs are." That's the advice of Richard I. Ostler, division manager for Marconi Instruments, Ltd., in Great Britain. As part of productivity improvement he instituted more frequent cost analyses, and he strengthened the cost and estimate department. As a result, management was able to monitor its actual financial condition more closely than before and to make adjustments sooner.

Auditing methods, too, can boost efficiency, especially since inflation has had a depressing effect on profits and cash flow. To alleviate this situation, some electronics companies have switched to a method of inventory valuation called LIFO for last in, first out.

The main attraction of LIFO at this time is that, by recording latest-acquired and more expensive inventory as being sold first, it pushes up costs and holds down profits. This reduces taxes, meaning more cash on hand, a smaller debt, and lower interest charges. Also, the adverse affect of LIFO on earnings and thus on stock prices is softened when the stock market is generally low or declining over a long period.

But LIFO is no instant panacea, warns Eli Gerver, associate national director of technical tax services at Touche, Ross & Co., one of the world's largest accounting firms. For one thing, he says, inflation will end eventually, putting a LIFO company at a disadvantage compared to firms with the more generally used FIFO (first in, first out) accounting.

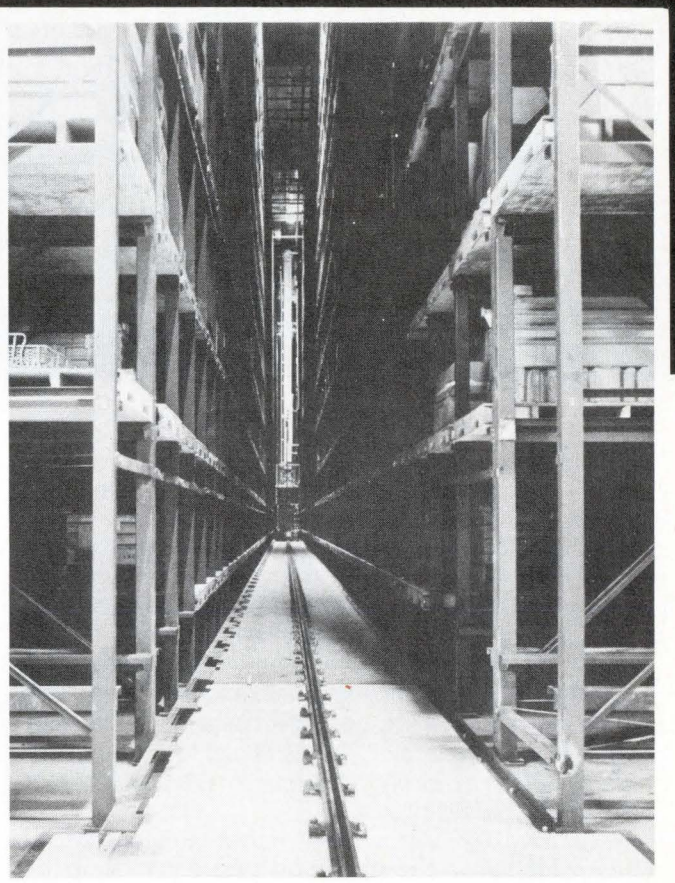
LIFO accounting tends to lower the value of inventory, he explains. What's more, switching back to FIFO could be a problem. To do that, a firm must demonstrate to the Internal Revenue Service that the new valuation method is better than the old—and not merely that it looks better on the balance sheets.

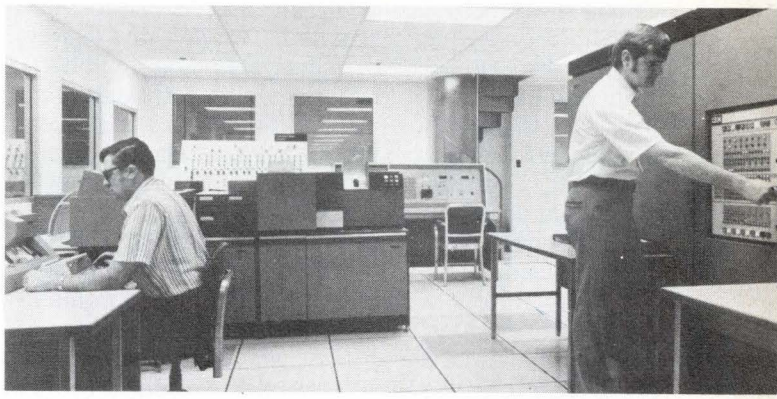
Selling harder

As for the sales function, improving its productivity today has been a matter of concentrating effort on specific targets and hitting them hard. It has also meant passing on some of the selling to distributors and sales reps to get more coverage with fewer sales calls.

This trend has been particularly apparent in the semiconductor market, where orders have fallen off sharply and sales efforts have had to be intensified despite lean times. In addition, sales departments have turned to computer information, not only for order handling, but for demand analysis by customer. As a result, selling has become more intense and more analytic than during the fat period of two years ago, because today it has become a matter of promoting recovery.

General Instrument Corp.'s Microelectronics group in Hicksville, N.Y., is using a number of techniques to boost its sales productivity. The company's worldwide





Productive storage. Automated purchasing and warehousing can make contributions to improving efficiency. At IBM Endicott's Materials Distribution Center (top), computer-controlled cranes patrol the shelves retrieving items ordered by an IBM 1800 (bottom).

sales organization is receiving greater factory support on new-product announcements via bulletins that are prepared and distributed at relatively low cost and within a few days of product-information availability. At the same time, says Edward A. Sack, group vice president and general manager, the field sales force is concentrating its efforts on major opportunities at a selected set of strategic accounts. "An increased emphasis is being placed on reliable forecasting techniques and identifying the specific action required to secure that business forecasted," he states.

Each GI salesman is provided with a computer printout "territory master" that identifies all major potential customers within his area and includes such key data as the customer's sales, the value of his components consumed, the type of components he uses, and other pertinent information. "Where there is a long-standing relationship with a customer," says Sack, "the account is handled directly from the factory, thereby improving communications and freeing the salesman to pursue new business opportunities."

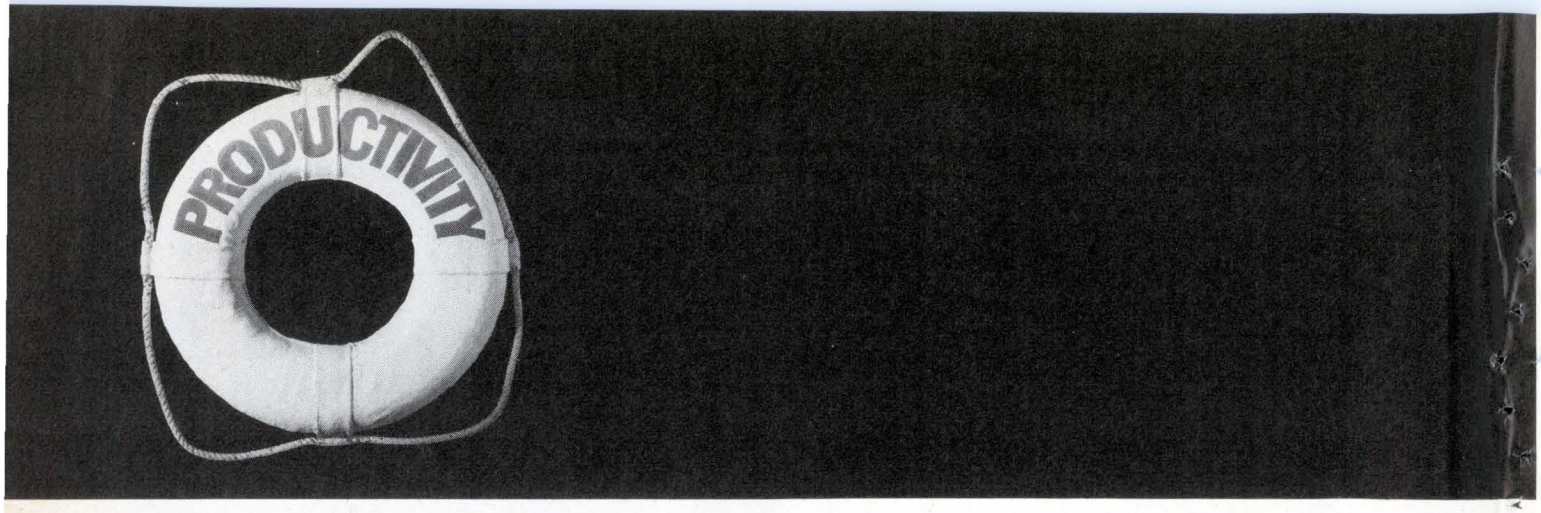
Other companies have simply transferred more of their sales load to their distributors. But before doing so, RCA Solid State division, Somerville, N.J., and Motorola Semiconductor Products division, Scottsdale, Ariz., put in considerable effort to boost distributors' capability. Motorola's answer was to have seminars for distributor salesmen to bring them up to a par with its own technically trained force.

RCA's bipolar-IC sales staff within a recent period of three months went to 857 of its distributors' customers. "Our distributors made up a list of people we should visit, and we went with the distributors," says Richard A. Santilli, group vice president. "We're going through the followup on this right now, and we're already beginning to see some results."

Distributors computerize operations

Because component manufacturers are shifting more of the sales effort to their distributors, the need for productivity improvement has become more important in this sector of the electronics industries, too. However, distributors have almost no assembly lines or factory operations to rationalize, so they have sought added efficiency in other areas. Today, like their components suppliers, they are looking much more carefully at each customer in terms of what he uses, how he uses it, and what products will fill the requirements. At the same time, they are trying to penetrate their accounts more deeply, yet at less cost per sale. These efforts have involved not only computerized inventory management, but communications, including the use in one instance of a satellite hook up.

Arrow Electronics Inc.'s Electronics Distribution division, Farmingdale, N.Y., for example, is now time-sharing Texas Instruments' computers in Dallas through some 20 CRT terminals at its nine stocking locations across the country. John Darcy, division president, says implementation of the system has resulted in an



increase in order-handling cost, but also an even bigger increase in profit "because I've been able to reduce dramatically my overhead expense in the expediting and purchasing area. At the same time, I've been able to get a much higher sales level per salesman. The net result is an over-all increase in productivity."

Under Arrow's new system, everything in the company's inventory is completely visible to salesmen, who can also see everything on order for a particular part number. Explains Darcy: "This isn't just for TI semiconductors, but for all of our products. We're paying TI for services as we use the system."

Previously, if an Arrow salesman in Boston, for instance, didn't have a part, he would have to pick up the tie-line and begin calling around each stock location until he found what he wanted. "Now," says Darcy, "all he has to do is punch in the generic part number—he doesn't even have to use a catalog computer number—and it tells him everything that's in stock at every branch, as well as what's on back order that hasn't been sold. The idea was to generate more sales ability without adding any sales people."

A computerized inventory-control system is currently under development at Jaco Electronics in Hauppauge, N.Y. Built around two Honeywell 6220 series computers—one at its main offices in Hauppauge, the other in Woodland Hills, Calif.—the system is designed to improve inventory utilization. "If we get an order for 1,000 pieces and we have 700 in Hauppauge and 300 in California, all 1,000 will be shipped to the customer. And the computer will know that if we have 700 in New York and 700 in California and we have 1,000 to be shipped, it's not to empty out New York's facility—it'll empty out a little bit of each. This will give us inventory turns, which is one of the things we're looking for," explains Joel Girsky, secretary-treasurer.

In yet another step to save money and improve communications between its stocking facilities, Jaco recently signed on with Western Union Corp.'s Westar Domestic satellite service between New York and California. "We can pick up a phone here in New York and get a Los Angeles dial tone, and if we want to talk to our suppliers, let's say, in the San Francisco Bay area, we would be paying for a toll charge from Los Angeles to San Francisco rather than from New York to San Francisco," says Girsky. Conversely, savings are realized by Jaco when its West Coast operation talks with its East Coast capacitor suppliers. "The savings are going to be very substantial to us—I figure it's the equivalent of three salesmens' salaries at the end of the year," Girsky estimates.

Purchasing improves its programs

Not to be forgotten in any program to tighten up the financial workings of an electronics organization is the important contribution of the purchasing department. Inventory imbalances have been a recurrent headache, and it has usually been up to purchasing management to put incoming supply and production-line demand on an even keel following a recessionary jolt. In recent times, purchasing has been aided by computers. And more recently, these computer programs have been finely tuned to handle the task of squeezing out more savings in inventory carry charges.

Varian Associates, for example, is implementing a new computerized purchasing system to be hung on its IBM System 370/155 at Palo Alto, Calif., headquarters. This system, which will take over 18 months to complete, will generate only half the 48 pieces of paper formerly used for each transaction, file seven instead of 28, and require one retrieval instead of eight.

The computer is not boss

Still, computer-controlled purchasing has to be considered a means, not an end. Arthur D. Little's Roger Long, a senior staff member in the Electronics Systems Group, says there is a danger in forgetting basic management skills in the mistaken belief that "the computer will do it." He comments, "I have had experience with several companies that had money problems because they didn't know how to implement automated data-processing systems for inventory control and manufacturing scheduling."

He tells of one manufacturer that wound up with several hundred thousand dollars worth of ICs that didn't fit into any products; the company's planning had failed to keep pace with actual inventory. "And this," says Long, "is typical, not unique. I've seen delivery schedules slowed down because management people have been depending so much on the computer that they didn't put some of their own business sense into the judgment." □

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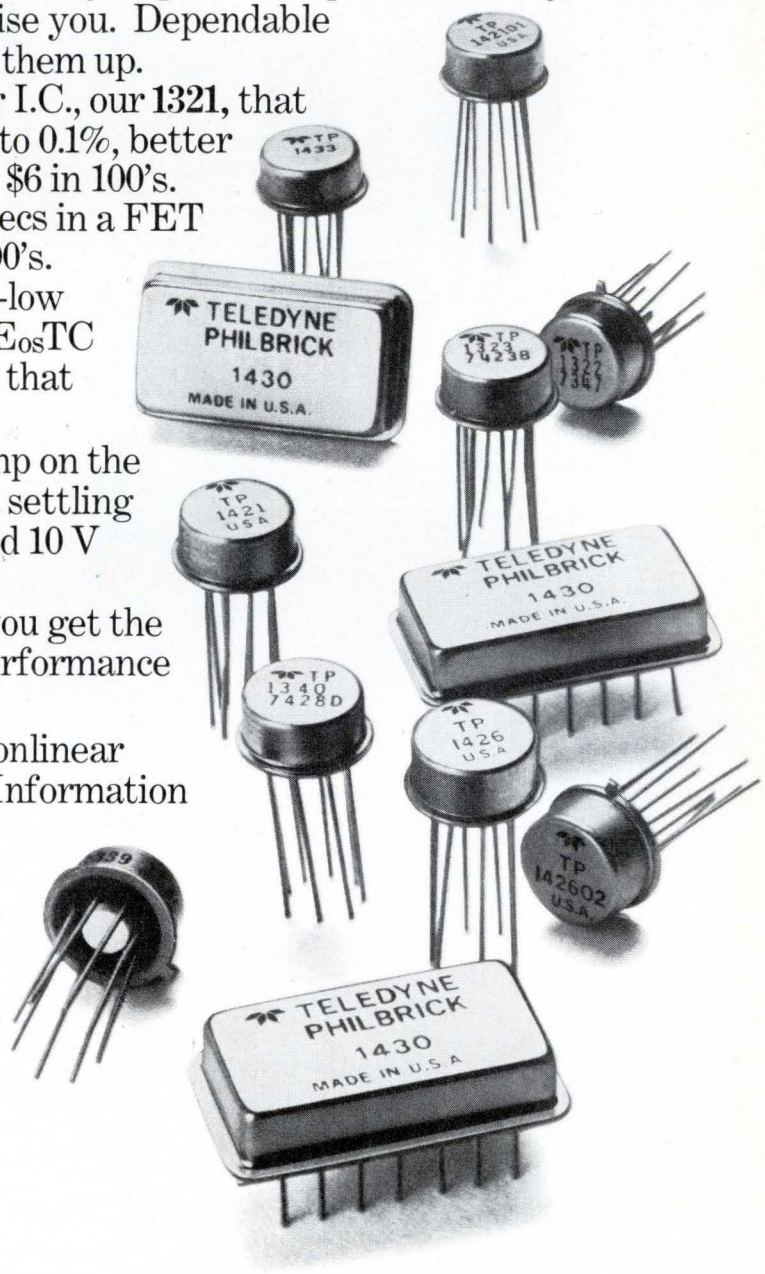
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Other worries trouble Washington

The National Commission on Productivity has been forced into a minor role by Watergate and governmental concern over unemployment; but there's a chance for its revival soon

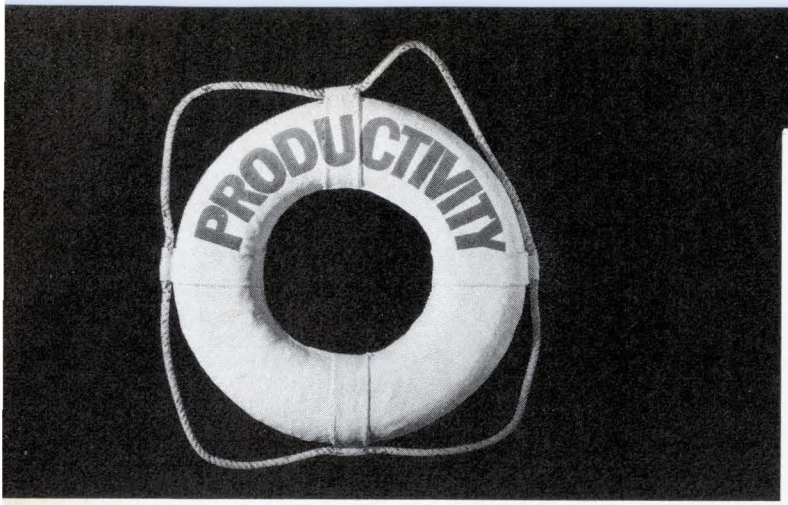
☐ A letdown awaits the electronics manufacturer who arrives in the nation's capital eager for advice and guidance on productivity. For little or no advice is available—even at the National Commission on Productivity, which is charged with developing and overseeing a national program to improve productivity. And the only hope that NCP might change lies with its newly appointed chairman, Vice President Nelson Rockefeller.

Just another agency lost in the Washington bureaucracy, the NCP has had little going for it since the economy turned down. The emphasis now is jobs, jobs, jobs; and the feeling around the capital is that there's not much point trying to improve the productivity of people who are out of work.

The commission's high point was in 1970, right after its creation by the then-powerful Nixon Administration. The President promised that NCP would "point the way toward growth in the years ahead." But like all temporary Government commissions, it eventually became clear that NCP could do little but point.

It could not push or shove industries or other Government agencies to undertake productivity improvement programs. It had no money to speak of, and even less statutory authority. In the years that followed, NCP's role dwindled till now it is but one of 87 Government commissions and boards. NCP's fiscal 1976 budget request for $2.5 million and 20 staffers does not stand comparison even with the $5 million and 398 jobs sought by the American Battle Monuments Commission, which watches over the nation's war memorials and military cemeteries.

Nevertheless, the commission may have gained a new lease on life with the almost unnoticed appoint-



ment of Nelson Rockefeller as its chairman. The Vice President is not the type of political operator to let something like this commission go under, particularly if it can be of use as a national platform.

Some Congressional staffers believe that the Vice President will try to resurrect the commission, but it is a tough job, even for a Rockefeller. Because of its small budget and staff, the commission has had limited interests. It has focused on such targets as food packaging and distribution, mass transportation, and health care.

Not only has the NCP ignored manufacturing productivity, but one staffer observes that "electronics has probably the lowest priority of any industrial group because its relative productivity is among the highest."

During its struggle for existence, the commission was shifted temporarily to the Cost of Living Council, but CLC itself died last year. Congress pushed through an appropriation, and the commission was reborn with a broadened title: the National Commission on Productivity and Work Quality (NCPWQ). That last part didn't mean much until Rockefeller, noted for his interest in quality of life and future priorities, entered the picture. In any event the Vice President's first task will be to get enough funding to keep it going rather than lurching along on a hand-to-mouth basis.

Needed—capital investment

Elsewhere in Washington there is a marked lack of agreement as to what to do about improving this nation's productivity. For instance, Ways and Means Chairman Al Ullman (Dem., Ore.) recently told a gathering of West Coast electronics manufacturers that the productivity and energy issues are inseparable. "Increasing productivity is in direct proportion to increased energy use in this country," he reminded the executives. The U.S. is now importing about 40% of its energy needs, and Ullman warned that "we will be importing about 60% if we are not careful."

Treasury Secretary William Simon sees the national productivity slump differently, however. He attributes America's productivity slowdown in the free world marketplace to its industries' laggard performance in capital investment compared to the Gross National Product. In recent years, the investment record of the U.S. private sector has been, he says, "the lowest of any



Productive commissioner? The appointment of Vice President Nelson Rockefeller to head the productivity commission may revive it.

major industrialized nation in the free world"—18% annually since 1960, as against 33% for Japan and 26% in West Germany and France.

Simon's solution for boosting industrial capital investment is: reduce the Federal share of the Gross National Product from its present level of almost one third; prune "the enormous proliferation of Government regulations" that encumber every phase of business and industrial life, and stimulate savings and investment, rather than consumption and Federal spending.

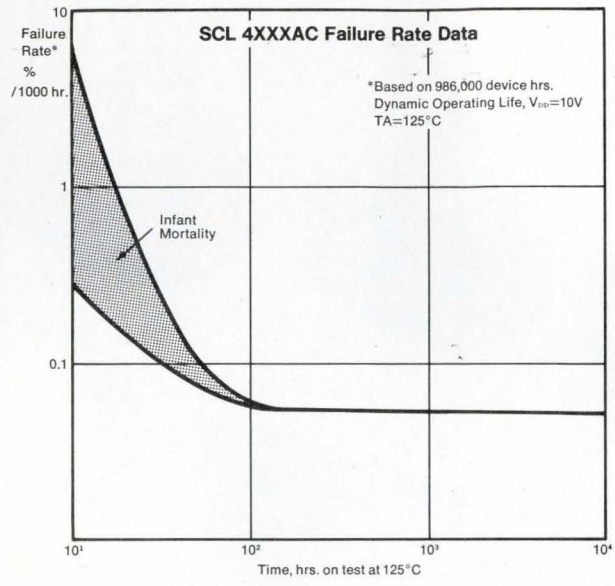
Behind the immediate challenge of improving the diminishing pool of investment capital, there lurks the problem of America's dwindling research and development base. The Productivity Commission's 1974 annual report—the third and most recent—put it this way: "The pace of productivity change in a technological society depends, to a great extent, on the application of scientific knowledge to production and, therefore, on the amount of resources devoted to R&D. For this reason, the decline in the proportion of the GNP spent for R&D in the U.S., and the increase in Japan, West Germany, and the Soviet Union are a portent of the diminution of the U.S. leadership in productivity."

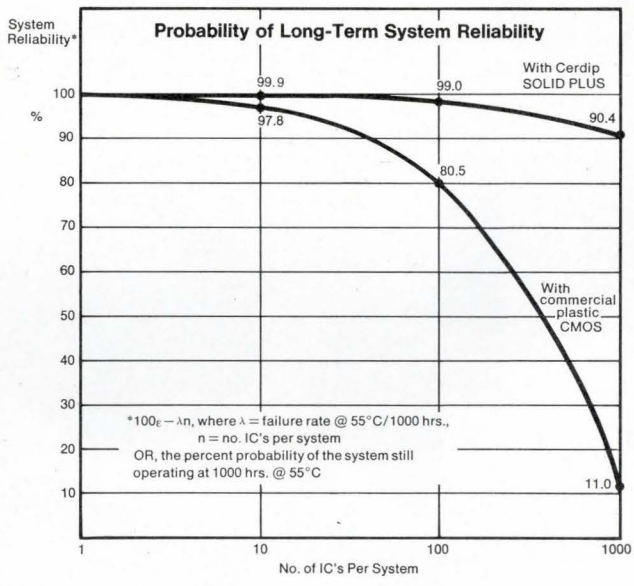
From Washington's point of view, it makes little difference that the electronics industries spend more per income dollar on R&D than most other industries. "All those figures show," observes one glum Treasury Department analyst, "is that the electronics business is the only one with a life jacket. But it is in the same leaky lifeboard as the rest of us." □

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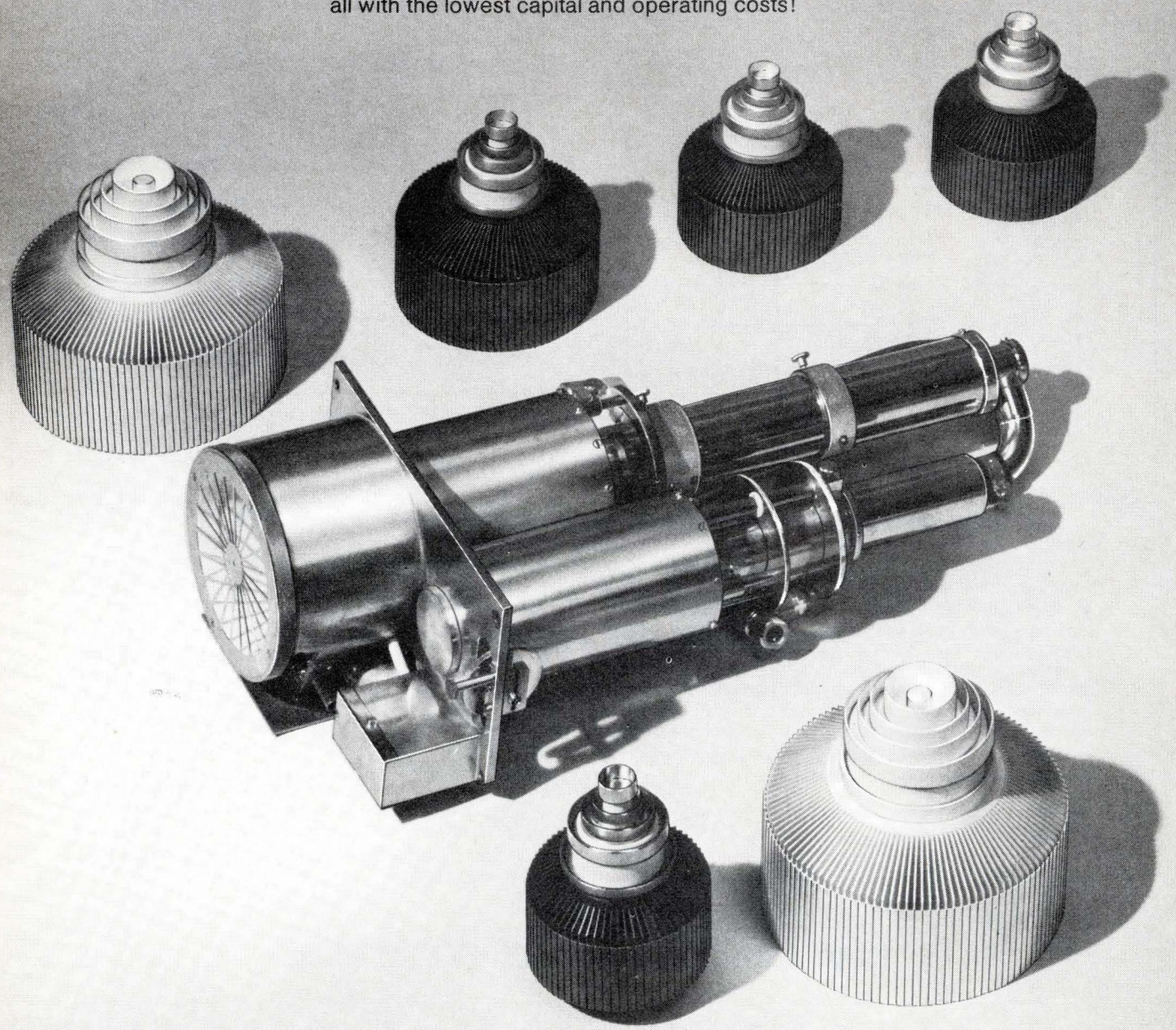
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Makers will go into latest developments with users at the 25th components meeting; hybrids are the highlight

by Lucinda Mattera, *Components Editor*

☐ Though no official celebrations will mark the Electronic Components Conference's silver anniversary in Washington, D.C., next month, the scheduled technical program will be perhaps the best kind of celebration there could be. It promises to be both exciting and informative about the effects that integrated circuits are having both in expanding the component base and in pushing hybrid and other component technologies to new heights.

The sessions encompass everything from the expected—cost-savings in connectors—to the novel—the latest in hybrid technology and applications—to the futuristic—fiber-optic communications and organic thin films for capacitors. It all backs up the statement of William E. Parker, vice president for technical and special components at Airco Electronics in Niagara Falls, N.Y., and this year's general chairman for ECC, that "we've broadened the scope of the conference without getting into systems, and we'll be covering state-of-the-art developments."

Parker says he tried to get a better program than in past years because "attendance hasn't been as good as we would like it to be." The program committee therefore added six to its numbers, and about half the 38 committee members were people who had not served previously. In recent years, less than 500 have attended ECC, a sad decline from the nearly 700 of the bustling late 1960s. The improved program will, however, Parker hopes, push attendance above 500, despite the depressed economy.

For the second year running, the Design Engineers' Electronic Components show will be held jointly with ECC. The idea is to give components manufacturers a showplace where they won't be swamped by equipment exhibitors, as can easily happen in large shows like IEEE

Intercon and Wescon. Almost twice as many are expected to exhibit as last year, or over 40, representing a cross section of the components industry. (For a look at several of the significant new products they will be introducing at DEEC, see p. 153.)

The two shows are, as usual, sponsored by the Electronics Industries Association and the Parts, Hybrids, and Packaging Group of the Institute of Electrical and Electronics Engineers. Also participating in the program will be two other IEEE groups—Manufacturing Technology and University Microelectronics—as well as the International Society for Hybrid Microelectronics.

Hybrids lead the way

Even though the monolithic chip may be replacing the hybrid circuit in broad-based application areas, the hybrid is still the way to go in vertical markets. Its strength is its adaptability—it tailors the monolithic chip to various different applications by interconnecting the chip with various other active or passive networks. The importance of hybrids to the industry is evident from the program, since five of the 14 sessions scheduled are devoted mainly to them and another five will at least touch on them.

For "Hybrid Applications," for example, session chairman John Powers, IBM Components division, Hopewell Junction, N.Y., has gathered together several successful new uses of the technology. One is an active telephone speech network from Bell-Northern Research, Ottawa, Canada, that's a wholly self-contained device consisting of transmitter, receiver, equalization and preamplifier circuits in a single package. Another, to be described by J.B. Schappacher of Harris Intertype in Melbourne, Fla., is a medium-power Class-C microwave transmitter amplifier originally developed for phased-array-antenna applications. It produces an impressive three quarters of a watt at a high 225 gigahertz. Then there's an unusual 5-kilovolt solid-state switch developed by Hughes Aircraft Co., Culver City, Calif. Used as a shorting device in a solar-cell array, it puts optical couplers on the same thin-film substrate as resistor, capacitor, and semiconductor chips.

The "Hybrid Technology" session will be concerned partly with the state of the art and partly with the reliability of hybrid manufacturing techniques, says its chairman, Robert Ilgenfritz of Raytheon Co., Bedford, Mass. Resistors and capacitors are not easily temperature-compensated, but Helmold Kausche of Siemens AG, Munich, will discuss a new metal system his firm has come up with for depositing temperature-compensated devices directly on the substrates of high-quality hybrid circuits. Other papers will cover a new optoelectronic solid-state switch, the reliability of interconnections, and an update of MIL-STD-883 leakage requirements for testing large (up to 100 cubic centimeters) hermetic packages.

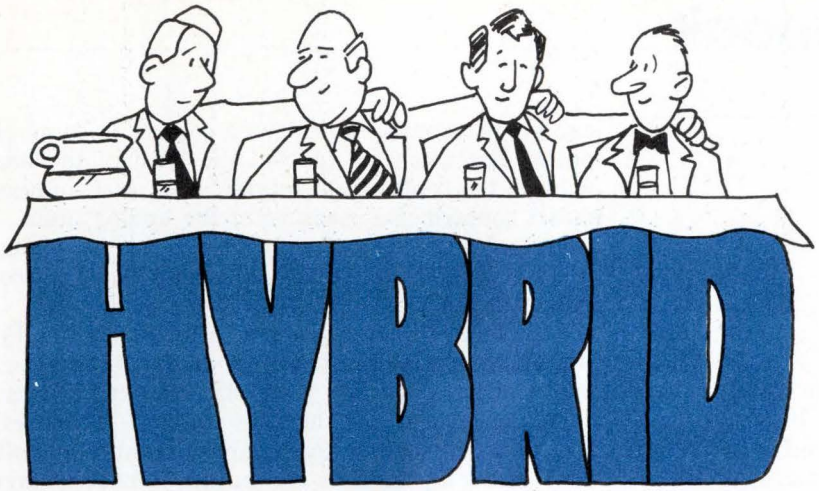
And as for testing hybrids automatically, "Computerized Testing" will focus on the total systems approach and the highly sophisticated methods and equipment available for this purpose today.

At several sessions, the audience will be invited to join in. In "Microelectronics Today," the session being run by the IEEE University Microelectronics group, an open discussion will follow the four invited papers. Session chairman is W. A. Porter from Texas A&M University in College Station, Texas, and the topics will be: the physical limitations of hybrid microcircuit materials; industrial trends in hybrid manufacturing; military applications of microelectronics, monolithic as well as hybrid; and an overview of university microelectronics programs throughout the U.S. and Europe.

The International Society for Hybrid Microelectronics, which is sponsoring the panel session on "Hybrid Standards Programs," is also looking for audience participation. Through these programs, ISHM is in the process of establishing standard specifications for hybrid circuits. Don Zimmerman, senior vice president for ISHM, who is with John Hopkins Applied Physics Laboratory in Silver Springs, Md., will be chairing the session. The society hopes to identify and discuss what additions, if any, are needed to its recently published document, "Hybrid Microelectronics Standard Specification Guidelines." Both military and commercial needs will be considered. Each member of the panel will be giving an informal talk providing background information on the guidelines.

The panelists include: M. Keller from the U.S. Department of Defense; I. H. Pratt from the U.S. Army





Electronics Command; J. P. Farrell from Griffiss Air Force Base in Rome, N.Y.; C. Vogelhuber from the Defense Electronic Supply Center in Dayton, Ohio; D. S. Walker from Sperry Gyroscope in Great Neck, N.Y.; and W. B. Burford of Westinghouse Electric Corp., Aerospace division, Baltimore, Md.

Discrete devices advance

Capacitors may be as old as the hills—almost—but the special-purpose type is relatively new on the horizon. Some interesting newcomers in this category will be described at the sessions on "Electrolytic Capacitors" and "Film Capacitors."

One low-impedance high-frequency electrolytic is a four-lead tantalum device that exhibits excellent impedance characteristics at frequencies as high as 50 megahertz, according to Charles Weaver and Thomas Kent of the Mallory Capacitor Co. in Indianapolis. Another low-impedance high-frequency electrolytic capacitor, this time made by Sprague Electric Co. of North Adams, Mass., is a stacked-foil aluminum unit whose low inductance, low equivalent series resistance, and high ripple-current capabilities are ideal for power-supply applications.

As for film capacitors, perhaps the most interesting is in a paper by Kazuo Horiguchi of Susumu Industrial Co. in Kyoto, Japan. He'll be discussing techniques for controlling the capacitance and stability of thin-film organic capacitors made by a process called glow-discharge polymerization and intended for use in microcircuits. Another paper by H. S. Veloric, J. Mitchell, and G. Theriault from RCA Laboratories in Princeton, N.J., explores the properties of metal-oxide-metal capacitors—high-Q devices that match the impedance requirements of the latest high-frequency power transistors.

Even the "Discrete Components" session has a highlight—an unusual extension of nickel thin-film technology. G. M. Meyer, M. D. Adler, and M. R. Teders from the Electronic Products division of Corning Glass Works, Corning, N.Y., tell how to use nickel thin films in transducer applications to detect temperature or fluid mass flow.

As usual, cost-savings is the thrust of the "Connectors" session. For example, William Schumacher and John Huber from AMP Inc. of Harrisburg, Pa., will be talking about a cost-saving connector for the gang termination of a new ribbon coaxial cable. Paul Krider, who is also with AMP, will describe a harness connector that permits a group of wires to be terminated simultaneously by means of insulation displacement. A new high-density connector for hybrid microcircuits, which squeezes 50 or more connections into an inch of board space, will be discussed by D. J. Kinniment from the University of Manchester, England. Also, Morton Antler from Bell Laboratories in Columbus, Ohio, will review alternates to gold for connector contacts.

In scope, the session on reliability is far-ranging. But the paper with perhaps the widest appeal will be given by G. A. Bulger of Bell Laboratories, Holmdel, N.J. His subject will be the stability of laser-trimmed thin-film resistors, and he'll be giving practical directions on how to choose the best resistor cut geometry and how to predict the resistor's end-of-life drift.

Other papers will cover the major failure modes of microwave power transistors, the reliability problems associated with beam-lead devices, the effectiveness of organic coatings for contamination control in hybrid circuits, and an analysis of the thermal-compression bondability of gold surfaces.

Also worth noting

Thick and thin films, strictly speaking, are the subject of the session on materials. For example, J. P. Gosselin, Fred Anders, and Richard Rosenburg of Dupont Co. Inc., Electronic Materials division, Niagara Falls, N.Y., will be talking about how some new thickfilm resistor compositions for cermet potentiometers and trimmers enable these devices to perform like more expensive wirewound and metal-film units. Two other papers—one from Fujitsu Ltd., Nagano, Japan, and the other from GTE Sylvania Inc., Needham Heights, Mass.—will deal with material systems in which thick and thin films can be used for the same microcircuit, cutting costs and reducing circuit size.

"Automatic Bonding" will provide a practical look at various aspects of integrated-circuit bonding technology. "Manufacturing Technology for the Late Seventies," being given by the IEEE Manufacturing Technology Group, will encompass: working with customers, producing high-reliability commercial ICs at low cost, fabricating prototypes using proven production methods, and coping with cost-control problems in the manufacture of thin-film hybrids. And "Fiber-Optical Communications—Components and Applications" will stress component requirements for the emerging technology in both military and commercial telephone applications. Also to be explored will be different techniques for cabling fibers in plastic jackets and different methods of connecting fibers to an optical source, optical detector, or another fiber bundle. □

Designer's casebook

Comparator IC forms 10-bit a-d converter

by James M. Williams
Massachusetts Institute of Technology, Cambridge, Mass.

This analog-to-digital converter uses an integrated-circuit comparator to provide an accurate 10-bit representation of an analog signal in 1 millisecond or in 100 microseconds, depending on the clock rate. The circuit, which costs only $13 to build, is accurate over the temperature range from 15°C to 35°C.

In addition to low cost, advantages include low parts count, low power drain, immunity from power-supply fluctuations, and capability to transmit data over two wires. Disadvantages include the necessity for a stable clock (although one clock can serve many converters), and dependence upon a capacitor for stability. The circuit may be sensitive to noise, but a small RC filter can be used for noise suppression.

Operation over extended temperature ranges is not recommended. If such use is necessary, however, capacitor C (Fig. 1) should consist of a 0.03 silver-mica capacitor in parallel with a 0.01 polystyrene capacitor.

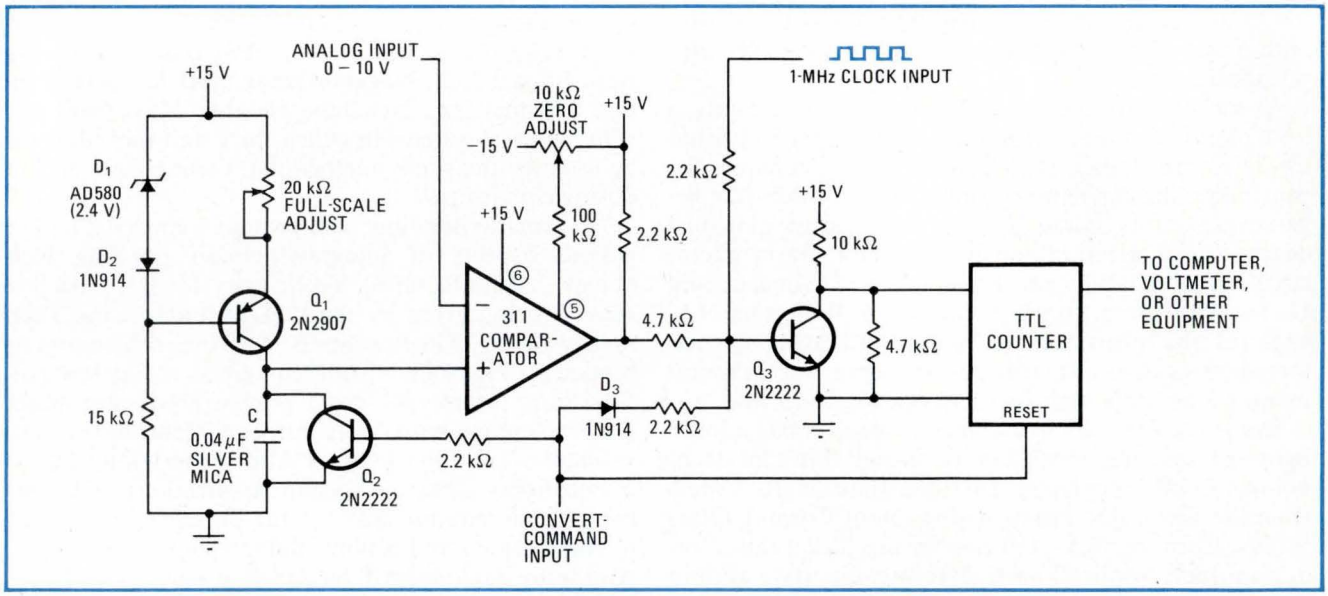
The digital output from this converter is the number of clock pulses counted during the time required for the capacitor to charge up to the level of the analog voltage. As the circuit diagram in Fig. 1 shows, the analog input can be any voltage from 0 to 10 v. This voltage and the voltage across the capacitor are compared in the IC. As long as the analog voltage is greater than capacitor voltage V_C, the comparator allows a counter to count clock pulses. But when V_C reaches the level of the analog voltage, the counting is stopped. The total number of pulses counted is a measure of the analog input. The charging rate of the capacitor is set so the pulse count is proportional to the voltage; e.g., 1,000 pulses corresponds to 10 v.

The detailed operation of the a-d converter in Fig. 1 is straightforward. Transistor Q_1, diodes D_1 and D_2, and the resistors constitute a constant-current source for charging capacitor C. The 2.4-v zener D_1 stabilizes the source against power-supply variations, and the voltage drop across D_2 matches the emitter-to-base voltage in Q_1, despite any temperature changes.

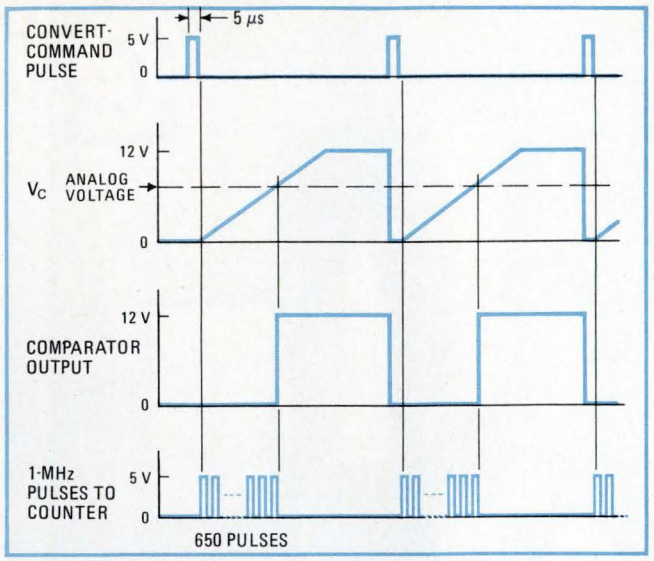
The type 311 IC compares the input voltage to the capacitor voltage V_C and controls transistor Q_3. The input voltage is applied to the inverting (–) input of the comparator, and V_C is applied to the noninverting (+) terminal. At quiescence, V_C is about 12 v, so the 311 output is high. This high signal keeps Q_3 on, so that the data line into the counter is grounded and no clock pulses are counted.

When a convert-command pulse is applied, transistor Q_2 turns on and discharges C, so that the 311 output goes to zero. Diode D_3 and the 2.2-kilohm resistor keep Q_3 on, however, so that no pulses can be counted during the convert command. On the falling edge of the command pulse, Q_1 begins to charge C linearly, and D_3 ceases to hold Q_3 on.

Now, because the output of the comparator is low, the clock pulses can turn Q_3 on and off, so that clock-frequency pulses are delivered to the counter. The combination of the 10-kilohm resistor and the 4.7-kilohm resistor makes the level of these pulses compatible with



1. A-d converter. Integrated-circuit comparator permits counting of clock pulses only while capacitor is charging up to level of analog voltage. With 1-MHz clock shown, conversion of 10-volt analog voltage to 10 bits (1,000 counts) takes 1 millisecond. If clock rate is 10 MHz, and C is 0.004 μF, conversion is accomplished in 100 microseconds.



2. Timing diagram. For an analog voltage of 6.5 V as in this example, 650 pulses are counted while capacitor charges up to turn off comparator output. Convert commands can be given at any rate up to 1 kHz for circuit as shown in Fig. 1.

transistor-transistor logic (TTL) in the counter circuit.

When V_C charges up to the level of the input voltage, the 311 output goes high again, which turns on Q_3 and grounds the data line so that no more pulses are counted. Fig. 2 shows the timing diagram for the converter operation.

To calibrate the counter, a 10-v signal is applied at the input, and the 20-kilohm potentiometer is adjusted so that 1,000 pulses appear at the counter for each conversion command. Then a 0.01-v signal is applied, and the 10-kilohm pot is adjusted so that 1 pulse is counted for each conversion. The unorthodox voltage-offset adjustment for the comparator corrects for incomplete discharge of C; the minimum voltage across C is V_{CE}(sat) of Q_2.

The circuit in Fig. 1 can convert 10 bits (i.e., count 1,000 pulses) in 1 ms. For conversion in 100 μs, the clock frequency must be 10 megahertz, and C must be 0.004 microfarad. Conversion commands can then be given at rates up to 10 kilohertz. □

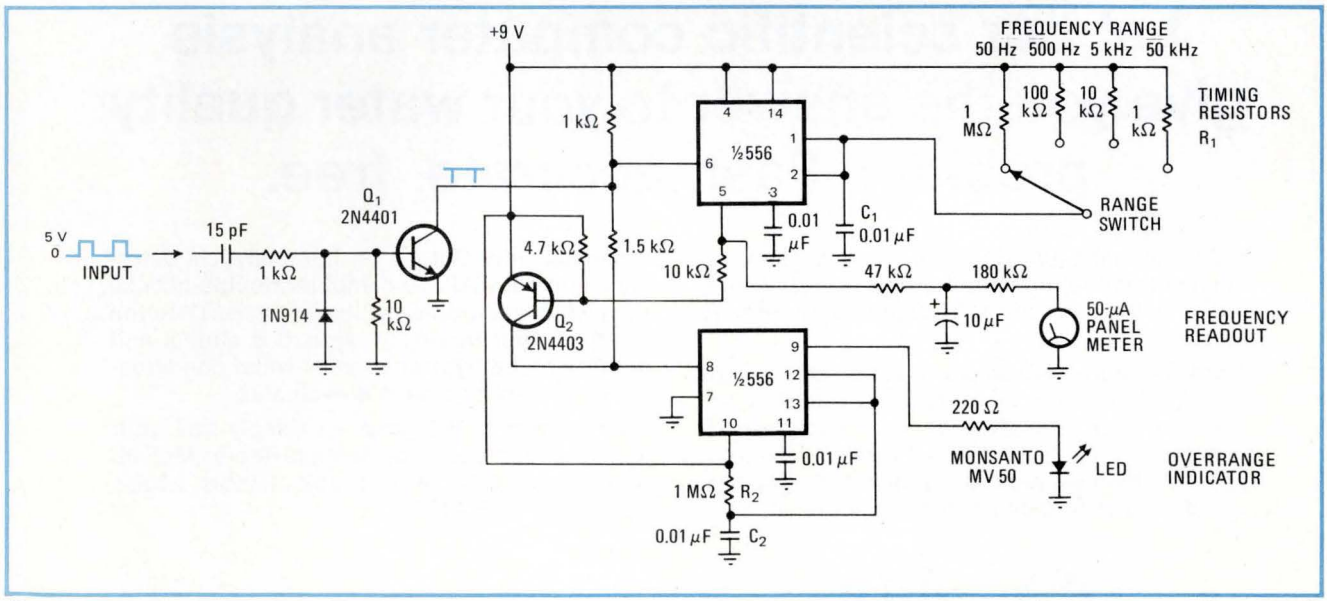
Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.

Overrange indicator can enhance frequency meter

by F. E. Hinkle
The Applied Research Laboratories, University of Texas, Austin, Texas

By making use of a 556 integrated circuit, which is composed of two 555 timers in a single package, an overrange indicator can be economically added to an analog frequency meter. A 555 can be used alone as a monostable multivibrator that is triggered by the frequency to be measured. To provide unambiguous measurements, however, the meter described here uses a second timer to flash a warning light whenever the input exceeds the maximum frequency setting. Although the technique of using monostables in analog frequency meters is not new, the use of new circuit developments makes the design economical and easy to implement.

When the range switch on this meter is set to the 50-hertz range, any input frequency from near dc to 50 Hz causes a panel meter to read correctly; e.g., a frequency of 42 Hz produces a meter reading of 42 microamperes. However, the meter reading is incorrect when the input



Unambiguous. Addition of overrange indicator to analog frequency meter warns when switch is set to wrong frequency range. Transistor Q_2 allows input signal to trigger LED monostable whenever input frequency is greater than meter range. Inexpensive and reliable circuit shown is useful from near dc to well over 20 kHz.



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frequency exceeds 50 Hz, and therefore a light-emitting-diode overrange indicator flashes. If the range switch is then moved to a setting higher than the frequency, the LED stops flashing and the meter again indicates correctly. For example, a 300-Hz signal would be measured on the 500-Hz range, and the meter would show 30 microamperes.

In the meter diagramed here, the upper portion of the circuit measures the frequency and has the 50-μA panel meter as its readout. The lower portion provides the overrange indication and has the LED as its warning light. These two portions of the circuit are driven by a common input.

The input signal is a rectangular pulse train; the pulses are differentiated to produce the negative spikes that are needed to trigger the timer. For a sine-wave or sawtooth input signal, a Schmitt trigger might be used to generate the negative impulses.

When pin 6 of the frequency-measurement monostable is triggered, pin 5 goes high. It stays high and delivers current for a time equal to $1.1R_1C_1$. This positive output pulse appears once for every cycle of the input frequency (unless the trigger impulse arrives while the output at pin 5 is already high). The current pulses, smoothed by the 10-microfarad capacitor, provide an average value that is shown on the microammeter.

At low frequencies, the output pulses are well separated, so the average current is low. At higher frequencies, however, they are closely spaced and approach a duty factor of about 95% at the upper frequency limit set by the range switch. Average current thus increases as the frequency increases. Resistors in the output circuit are chosen so that the average current is 50 μA at the maximum frequency in each range.

If the input frequency exceeds the meter range, a trigger spike arrives while the output is already high. As a result, that input cycle is not counted, so the frequency meter indication is erroneous.

To warn that trigger impulses are arriving while pin 5 is high, pin 5 is also connected to the base of pnp transistor Q_2. When pin 5 is low, Q_2 conducts and holds pin 8 high, thus preventing the warning-indicator monostable from being triggered. But when pin 5 is high, Q_2 is turned off; a negative input spike that reaches pin 8 therefore can trigger an output from pin 9 that flashes the LED. The duration of the flash is $1.1R_2C_2$. □

Pulse-frequency doubler requires no adjustment

by Thomas McGahee
Don Bosco Technical High School, Boston, Mass.

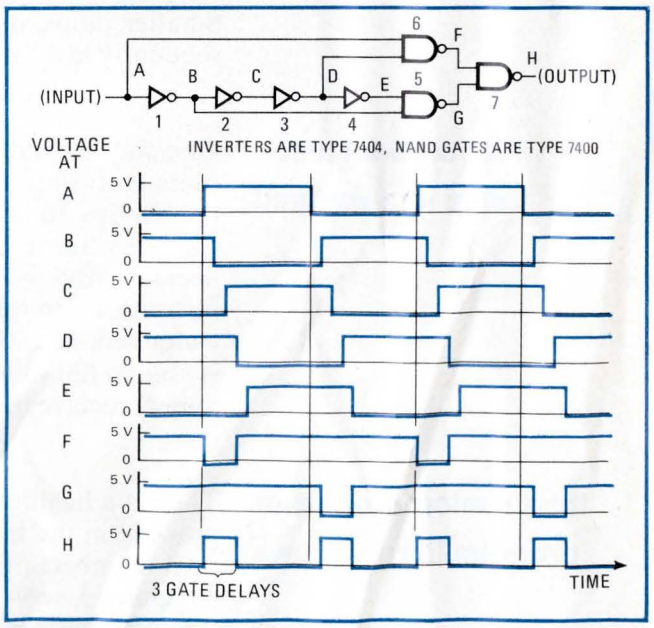
Sometimes a frequency doubler is needed in a digital system, and unfortunately most doubler circuits have to be adjusted for a particular operating frequency. However, this circuit, which has operated successfully in a specially designed divide-by-N counter, requires no adjustment over a range from near dc to 10 megahertz.

When a signal pulse passes through the circuit, each inverter introduces a small delay, typically of 20 nanoseconds, in addition to inverting the pulse. For example, the signal at point D inverts 60 ns after the input signal at point A has inverted; thus, gate 6 continues to have high signals at both of its input terminals for 60 ns after the input at point A changes from low to high. As a result, the output from gate 6 (i.e., point F) will go low for 60 ns after a positive-going transition at the input to the circuit.

Somewhat the same thing occurs at gate 5, except that it develops a 60-ns low output after a negative-going transition at the input. In the circuit diagram, inverters 1, 2, and 3 all serve double duty in producing these 60-ns low pulses at points F and G. This design reduces the number of gates needed.

The pulses from gates 5 and 6 are fed to the terminals of gate 7, which produces a positive pulse 60 ns wide every time either one of its input terminals goes low. Since one terminal goes low on the leading edge of each input pulse at point A, and the other terminal goes low on the trailing edge of each input pulse at A, the frequency of the output pulses at point H is twice the frequency of the input pulses at point A.

The output is in the form of positive pulses that are 60 ns wide. There is a 20-ns difference in the spacing between successive output pulses because the portion of the circuit that comprises the negative-going edge-detector has one more inverter stage than the positive-going edge-detector section does. This slight asymmetry is noticeable only at the highest frequencies. If particularly slow input signals are used, it is a good idea to place a Schmitt trigger just before the input. □



Frequency doubler. Propagation delays through inverters cause NAND gates 5 and 6 to go low for 60 nanoseconds following the rising and falling edges, respectively, of input pulse. Therefore output goes high twice as often as input.

Engineer's newsletter

Noise earmarks faulty capacitors

Occasionally, the value of a self-healing metalized-plastic capacitor will drift excessively after the unit has been in use for some time. You can spot these troublesome devices by a noise measurement before they have a chance to degrade circuit performance, notes Siemens AG, Erlangen, West Germany. The unwanted capacitance change is due to latent defects in the metal layer of the unit's case. **Because of those defects, a potentially defective capacitor will exhibit a noise voltage of a few hundred nanovolts,** even if the other component parameters, such as the insulation resistance, dissipation factor, and capacitance value, are within specification.

IEEE again compiles standards

Having trouble putting your hands on that critical spec? Standards for everything from accelerometers to X rays are once again listed in the 1975 IEEE Standards Catalog. This wide-ranging compilation includes more than 350 publications by subject and by numerical sequence and is available free from the IEEE Standards Department, 345 E. 47th St., New York, N.Y. 10017

A crucial ratio in jewel-bearing design

Designing a jeweled-bearing system for a meter, relay, accelerometer, or other sensitive application? If you're using a V-jewel bearing, the most important design parameter, according to a tip from Bird Precision Jewels, Waltham, Mass., **is the ratio of the jewel radius to the pivot radius.** For optimum over-all performance they recommend a 3:1 ratio. Higher ratios, while yielding enhanced sensitivity, lead to bearing assemblies with poor damping and high susceptibility to damage. Smaller ratios, on the other hand, result in excessive friction and consequently in a "sticky" movement.

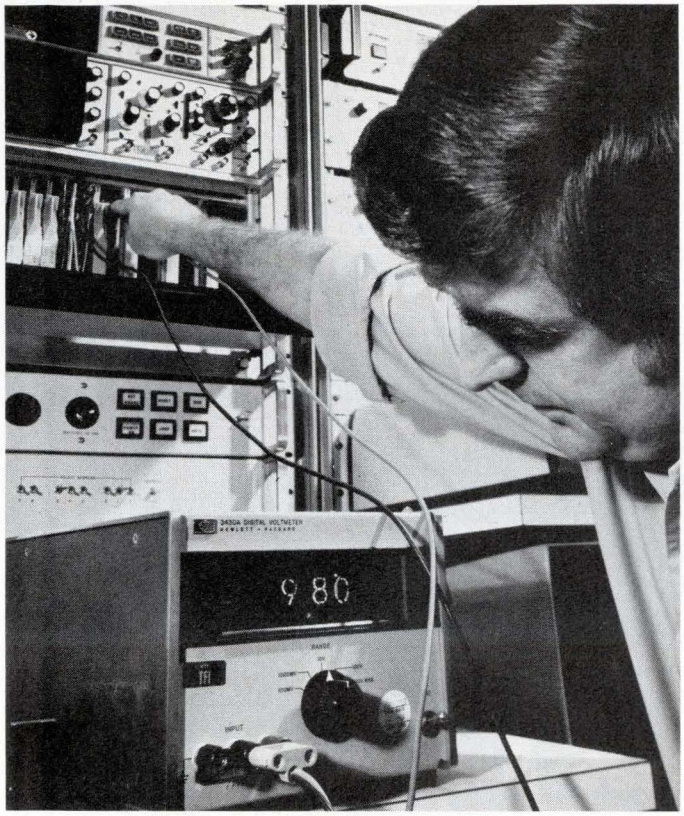
An off-beat test—ship it to yourself

One way to find out the condition of your products when they get to users is to ship a test model to yourself. Since 95% of the products of the Philips Industrielektronik operation in Sweden are exported, the company has to constantly worry about transport damage, which is especially troublesome for sensitive instruments. **So periodically it sends instruments to other Philips facilities around the world, asking that the containers be returned to Sweden unopened.** In this way, the company is able to find out at first hand how the instruments perform when customers receive them.

Intel's microprocessor program library grows

There's a healthy group of programs and routines for microcomputers growing in the industry. And, if you're interested in trading or anteing up a membership fee **you can become a member of Intel Corp.'s Microcomputer Users' Libraries, which now include more than 55 non-proprietary routines written for Intel's 8008/8080 and 4004/4040 microprocessors.** The 12-month subscription is free if you contribute a "qualified" program. Otherwise, it costs $100. Contact Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051. **—Laurence Altman**

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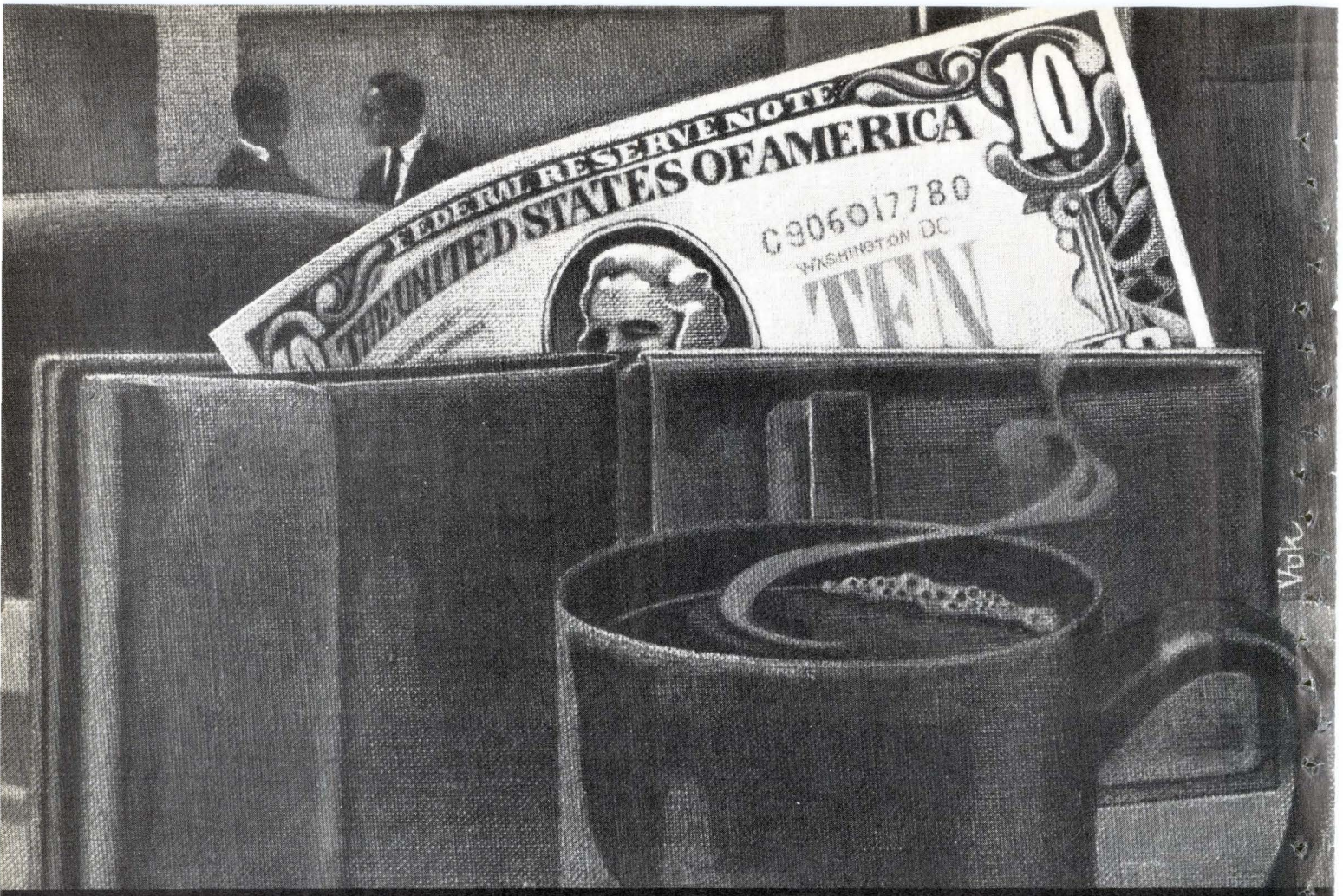
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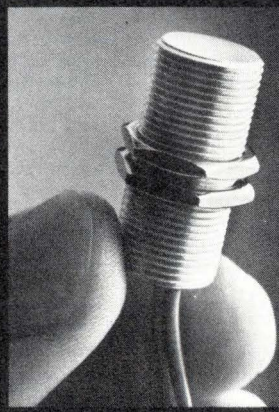
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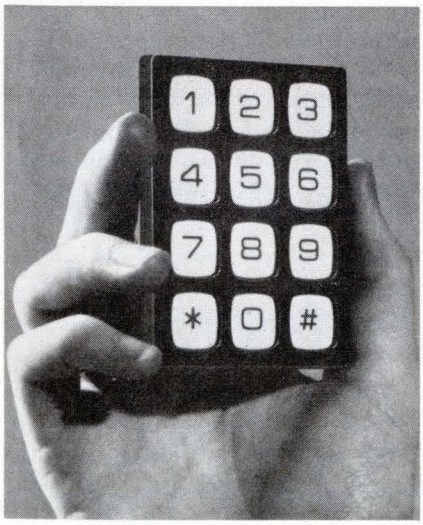
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Circle 152 on reader service card

Diversity of devices to be spotlighted at 2nd components show

The second Design Engineers' Electronic Components (DEEC) show, to be held at the Statler-Hilton in Washington, D.C., May 12–14, will be nearly twice as large as last year's exhibition. And a preview of the components to be displayed indicates that variety will be the keynote. There will be connectors and switches, chip components and resistor networks, trimmers, potentiometers, and inductors. Following are some of the more significant products to be shown.

Keyboards are touch-sensitive



Now that solid-state elevator controls and such consumer products as the Frigidaire electronically controlled kitchen range have paved the way toward general acceptance of zero-travel or limited-travel switches, Centralab feels that the time is ripe to push the idea of completely flat front panels for a variety of applications from home-entertainment equipment to industrial control panels. These panels would consist of smooth, tough, projection-free, transparent plastic membranes with displays and indicator lamps mounted behind them, and with touch-sensitive switches or keyboards forming an integral part of their structure.

Naturally, such panels will be made largely as custom devices, but Centralab has come out with two standard keyboards that are expected to prove useful in a substantial number of situations. These keyboards are not capacitive switches; they actually provide a contact closure when they are activated by 2 to 4 ounces of force. This force causes the switch's tough plastic film to deflect about 0.004 inch—enough for its metalized backing to effect a contact closure. Despite the tiny travel distance, contact resistance is kept below 0.1 ohm, contact bounce is kept below 5 milliseconds, and open-circuit resistance is kept above 10 megohms. Maximum voltage is 50V, and current is 200 mA.

The two standard products that Centralab will be showing at DEEC are the MK1200 and MK1600 keyboards, which are 12-position and 16-position single-pole, single-throw units, respectively. Each will sell for from 50¢ per switch closure (in unit quantities) down to 20¢ per switch closure (in quantities of 1,000). If positive snap-action is desired, the keyboards can be supplied with a plastic bubble which provides a tactile feedback.

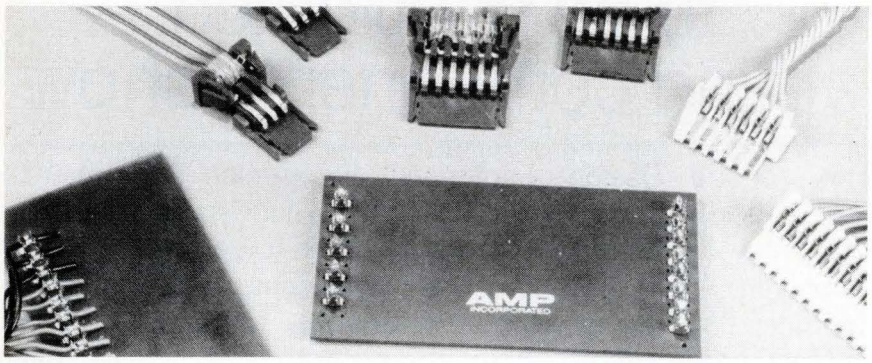
In addition to simple single-pole single-throw configurations, multiple contacts can also be provided. Further, timed sequences of contact

closures can be designed into a switch, so that the contacts close in a definite order as the pressure is increased.

In addition to the keyboards, both standard and custom, Centralab is offering its membrane switch as a single unit. Housed in the ½-inch-square package used for the Magic Dot switches before Magic Dot was acquired by Centralab, the push-button switch is intended for industrial applications.

Centralab Electronics, 5757 N. Green Bay Ave., Milwaukee, Wis. 53201 [401]

Connectors eliminate need to prestrip wires



Reliability of the insulation-displacement method of terminating wires to connectors has long been proven in the telecommunications industry. A series of hermaphroditic contact connectors from AMP are supplied pre-loaded with contacts designed for this technique, which eliminates the time, expense, and tooling required for prestripping wires.

The new Lace-n-Lok connectors accept 24-22 AWG solid, fused-stranded or stranded wire and are available in 3-, 6-, 9- and 12-pin versions with contacts on 0.150-inch centers. They are housed in a flame-retardant thermoplastic material. Housings have plastic snap fingers for easy panel-mounting. Connector halves are held together with positive latches to insure mating during shock and vibration. The system lends itself to manual, semiautomatic, or automatic mass termination with special tooling furnished to the customer by AMP.

The company already has manual and semiautomatic power tools for wiring the new connectors. Under development is a fully automatic machine for terminating both mating halves of a connector at the same time.

Heart of the connector is a special wire-terminating assembly where insulation is displaced and wire deformed. There are two slots in the wire-terminating area, each having a U-shaped configuration with a funnel-shaped area at the top. The slot nearest the connector contact makes the electrical connection, while the one at the end of the housing acts as a built-in strain relief. Using AMP's special tooling, insulated wires are positioned into the uppermost portion of the two slots. Then the tooling cuts the wires and forces them into the slots, displacing the insulation and deforming the wire. This deformation of the wire conductor breaks down any oxides present on the wire, and the wiping action cleans the slot walls.

At the same time as the wire is being deformed, the walls of the slot are forced outward slightly, and the stored spring-energy causes the two side walls to function like opposing cantilever beams, maintaining contact pressure and ensuring a gas-tight metal-to-metal contact. The constant pressure exerted on the wire by the walls of the slot give this technique the ability to maintain contact forces for a long time. Any wire creep is easily compensated for by the stored energy.

Despite the fragile appearance of the completed terminations, AMP's engineers say that reliability of the new method, both short- and long-term, is excellent. For instance, this technique is being used in the telephone industry to terminate wires that must have a projected life of 40 years. Further proof of reliability is cited in results of a series of tests that AMP ran on the friction resistance of mated halves and wire-termination resistance. These tests consisted of subjecting connectors to five cycles of thermal shock, 96 hours of 95% relative humidity at 40°C, and vibration to MIL-STD-202D method 201A. Friction resistance during testing did not exceed 3 milliohms, and wire-termination resistance showed little increase.

AMP Inc., Harrisburg, Pa. 17105 [402]

Kits have resistor, capacitor chips for watches

Manufacturers of digital watches usually buy resistor and capacitor chips individually. Now, however, they can buy them in kit form from Varadyne Industries, saving as much as 20% to 25%. Each kit, which contains four chips, will sell for 25¢ to 40¢ in production quantities. Delivery time is six weeks.

The capacitor chips are available in five sizes, ranging from 0.050 by 0.050 by 0.050 inch to 0.120 by 0.095 by 0.050 in. There are also three different dielectric materials, rated as ultrastable (NPO), stable



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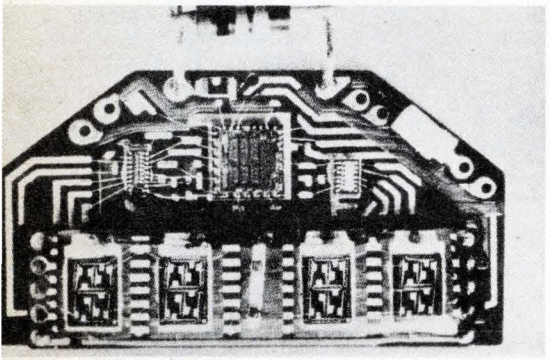
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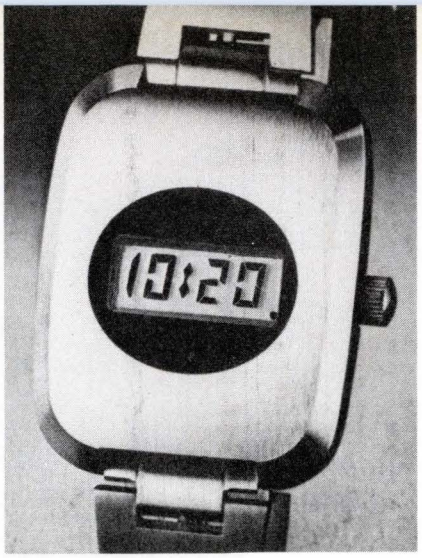
Fotoceram Products Group

CORNING

Corning Glass Works
Corning, New York 14830
(607) 974-8583

Circle 155 on reader service card





(BX), or general purpose (GM). Capacitance value can be as low as 10 picofarads or as high as 0.47 microfarad.

Sizes for the resistor chips are 0.050 by 0.050 by 0.020 in., 0.075 by 0.050 by 0.020 in., or 0.100 by 0.050 by 0.020 in. Resistance values range from 10 ohms to 50 megohms, while power rating is 75, 100, or 150 milliwatts.

Varadyne will also be showing a new line of high-reliability capacitor chips for microwave applications. The capacitance value of these chips changes by a mere 0.05% over the frequency range of 1 kilohertz to 1 gigahertz. Additionally, for values of 10 pF or more, they have a minimum Q factor of 10,000 at 100 megahertz.

Two sizes are available: the type MW-1 is a 0.050-in. cube, and the type MW-2 is a 0.100-in. cube. Voltage rating is 100, 200, 300, or 500 V, depending on the capacitance value, which ranges from 1 to 100 pF for the type MW-1 and 1 to 1,000 pF for the type MW-2. Temperature coefficient is ±30 ppm/°C from −55°C to +125°C.

Varadyne Industries Inc., 1547 Eighteenth St., Santa Monica, Calif. 90404 (For further information on the resistor-capacitor chips, circle 403 on reader service card; for additional information on microwave chips, circle 340).

Thick-film dividers go to 30 kilovolts

Although rated for up to 30 kilovolts, a new series of thick-film high-voltage resistor divider networks provides ratio accuracies as tight as 2.5% and temperature coefficients of ±400 ppm/°C. The units, available in both ceramic-substrate and encapsulated versions, are intended for television, power-supply, and other high-voltage applications.

Series RD networks have a power rating of 2, 3, or 5 watts and a voltage rating of 10, 20, or 30 kilovolts. Resistance values range from 0.5 to 10,000 megohms, with tolerances of 10% or 20%. Resistance ratios also span a broad range of values—from 1:1 to 10,000:1.

Encapsulated versions of the networks, which are compatible with printed-circuit boards, can be as small as 1.10 by 1.10 by 0.150 inches, increasing to 2.10 by 1.10 by 0.225 in.

The ceramic-substrate models are somewhat smaller. They measure from 1.0 by 1.0 by 0.025 in. to 2.0 by 1.0 by 0.025 in.

IRC Resistors, Div. of TRW Inc., 401 North Broad St., Philadelphia, Pa. 19108 [404]

Jumper module mounts in two directions

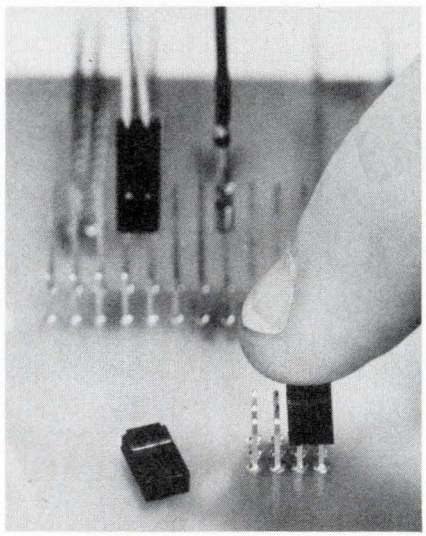
Hardwired or wire-wrapped changes are often made in programing motherboards or backplanes of minicomputers, computer peripherals, modems, or process control instrumentation.

A compact modular push-on jumper system from DuPont's Berg Electronic division is suited for making these changes on a matrix of 0.025-inch square pins on 0.100-in. centers (standard dimensions for wire-wrap pins).

Berg's Mini-Jump connector, which shorts pairs of 0.025-in.-square or 0.028-in.-round pins, is pluggable in both the X and Y directions on 0.100-in. centers. Versions having from two to 10 positions are available for shorting from one to five pairs of pins. A two-position Mini-Jump has a polyester plastic housing that is 0.385 by 0.200 by 0.100 in.

Female receptacles in the unit are of a dual-metal construction—a body of ¼-hard brass having excellent electrical properties and a heat-treated beryllium-copper spring for applying a consistent normal force to the pin. An internal strip shorts each pair of pin receptacles in both the X and Y directions.

After a great number of insertions, the reliability of the connector depends on both the contact plating



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Circle 157 on reader service card

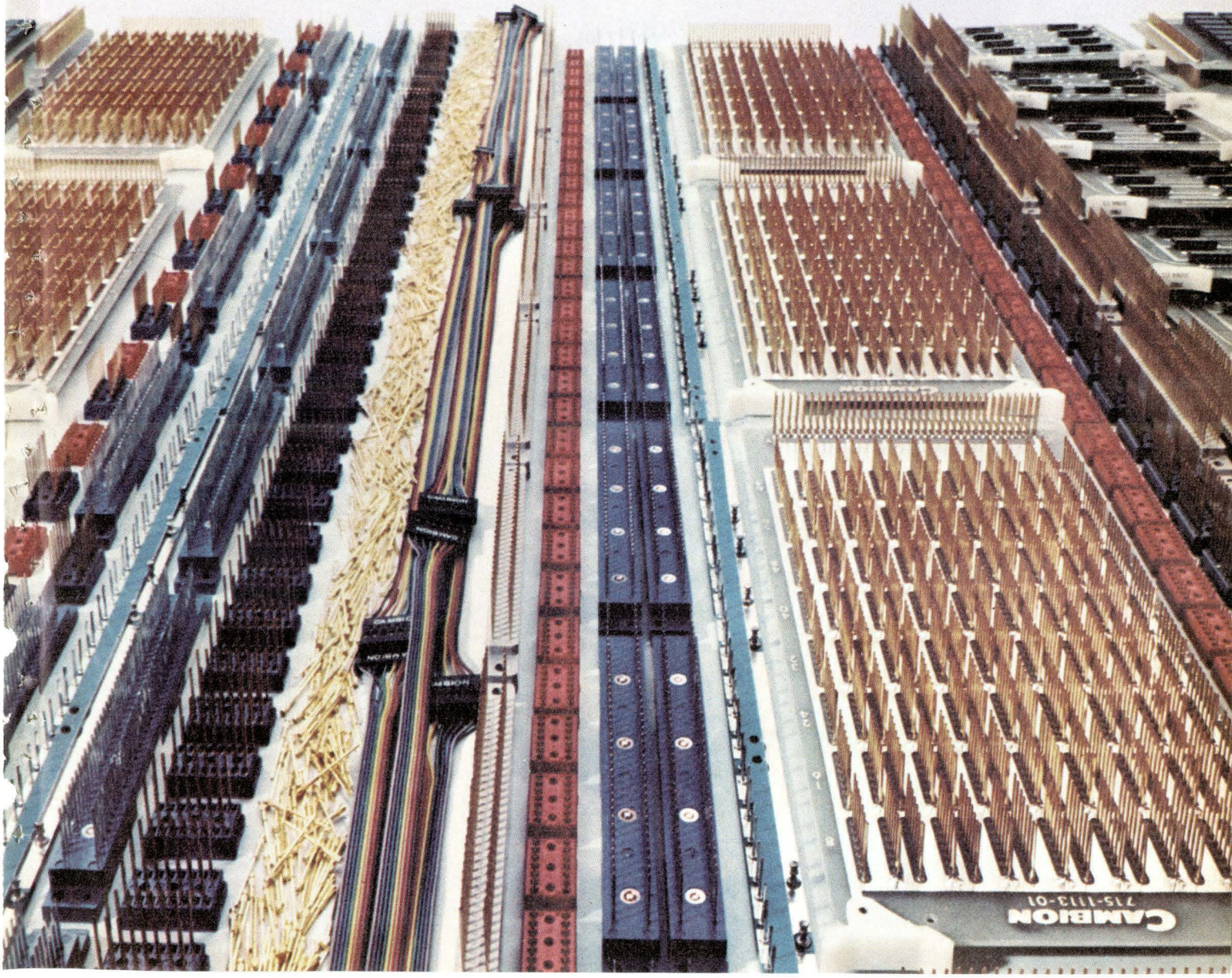
We also offer expanded NC wire-wrapping service to speed economical production of your IC system designs.

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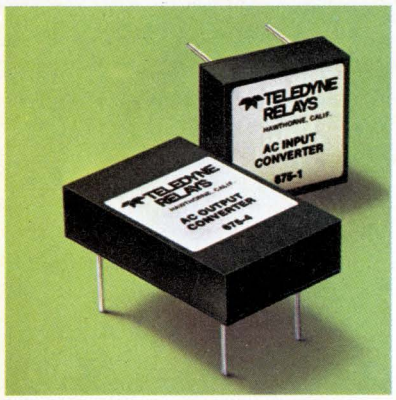
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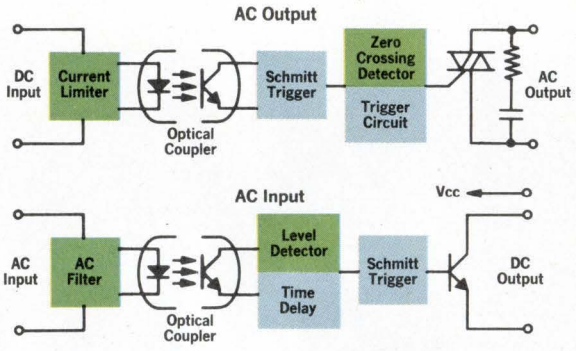
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Get on board with Teledyne I/O converter modules

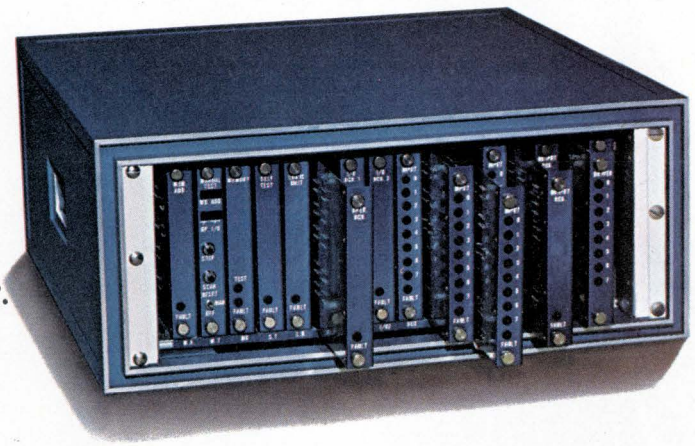


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Typical Functional Diagrams

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Telephone (213) 973-4545

Photo courtesy of Datametrics a subsidiary of ITE Imperial Corporation.

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Telephone: 06121-302031/2 Telex: 04-186851 (Trel-D)

Heathrow House, Bath Road, Cranford, Hounslow, Middlesex, U.K.
Telephone: 01-8972501 Telex: 935008

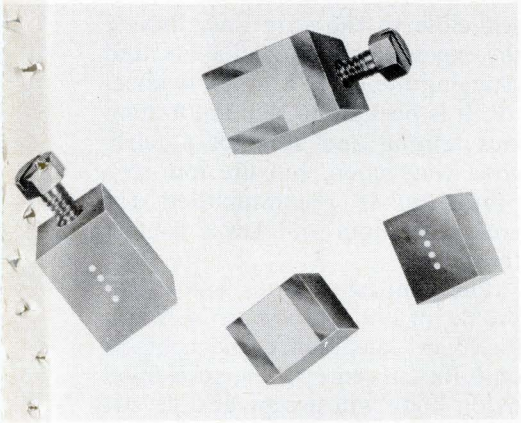
and the environment. Typically, platings are solder, gold, or copper-nickel with a gold dot. The latter plating is said to be capable of more than 1,000 insertions, regardless of the operating environment.

DuPont Co., Berg Electronics Div., Route 83, New Cumberland, Pa. 17070 [405]

Chip inductor is variable

Chip components until recently were fixed-value devices. But now a variable chip inductor has arrived, to join other variable chip components. It comes in 37 standard values from 0.01 microhenry up to a sizable 1,000 μH and can be varied ±20% about the central value.

Intended for use in thick-film hybrid integrated circuits, the CVM-Series has adjustable screw-in cores.



The chips are electromagnetically shielded for minimum coupling in densely packed circuits, and the platinum-gold pads on their undersides make them easy to bond to substrate metalization. Unusual in chip inductors, too, is the third terminal pad, which is connected to the adjustable core for more effective grounding and shielding of the component. The units measure 0.150 by 0.200 inch and have a maximum height of 0.160 in. Their price, in lots of 1,000 pieces is $4.30 each.

The CM-Series also is shielded and also has platinum-gold pads. The chips are offered in 61 standard values over the same range as the CVM-Series at a standard tolerance of ±10%. They also have the same area, but the maximum height (for the highest-inductance unit) is 0.130 in. Pricing is $3.60 each in lots of 1,000.

In addition to its chip inductors, Airco will be showing three new axial-lead fixed rf inductors at DEEC. The type 05 conformally coated and the type 10 molded units are both unshielded devices that come in 49 standard values from 0.1 to 1,000 μH. Dc resistances range from 0.2 ohm for the 0.1-μH unit up to 130 ohms for the 1,000-μH device. The type 10S shielded inductor is available in the same range of values as the unshielded units, but it is a higher-Q device. Its maximum dc resistance for the 0.1-μH version is only 0.06 ohm, and the resistance for the 1,000-μH version is only 65 ohms. All three leaded inductors have a sea-level dielectric strength of 300 v rms.

Airco Speer Electronics, Bradford, Pa. 16701

Circle 406 for information on chip inductors

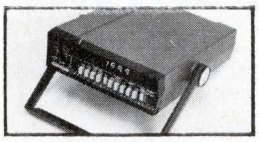
Circle 339 for information on leaded inductors

Variable resistors are low-priced

Keeping in line with the steady decline in trimmer prices, a series of ⅜-inch-diameter single-turn cermet trimmers from CTS of Berne Inc. in Berne, Ind., costs as little as 25¢ each in production quantities. The series 375 units are intended to compete with similar trimmers being made by the Helipot division of Beckman Instruments Corp. in Fullerton, Calif., and the Trimpot division of Bourns Inc., of Riverside, Calif.

The adjustment knob of the CTS

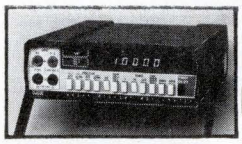
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The Fluke 8600A. Here's the automatic 4-1/2 digit DMM that comes out way ahead compared to the ten top competitors. It's the only DMM with five ranges of ac/dc volts to 1200 volts and one of three with five ranges of ac/dc current to 2 A. It's one of four with six ranges of resistance to 20 megohms and one of two with autorange on all ranges plus individual manual range selection.

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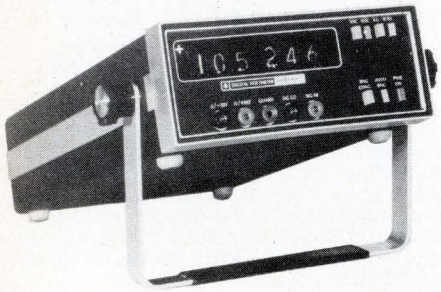
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New products

devices doubles as a cover to protect them against dust, oil, and other contaminants. Standard resistance values range from 20 ohms through 1 megohm, with a value tolerance of ±20%. Power rating is 1 watt at 40°C, and temperature coefficient is ±100 ppm/°C between −55°C and +125°C. Moveover, they provide a settability to within 0.03% and hold contact-resistance variation to 2%.

Another new variable-resistor product is being announced by CTS of Elkhart in Elkhart, Ind. It's a professional-grade carbon-composition potentiometer that sells for about 55¢ each in production quantities. Because it is a low-noise device, the model PG450 is ideal for instrumentation applications. Measuring 15/16 inch in diameter, the unit has special lubrication to achieve its smooth-feel adjustment.

Resistance values can range from 500 ohms to 15 megohms, at tolerances of ±30% or ±40%. Power rating is from ¼ to ½ W. The PG450 also has a multipaddle contactor.

CTS of Berne Inc., 406 Parr Rd., Berne, Inc. 46711 [407]
CTS Corp., 905 Northwest Blvd., Elkhart, Ind. 46514 [410]

Connector plugs into flexible circuits

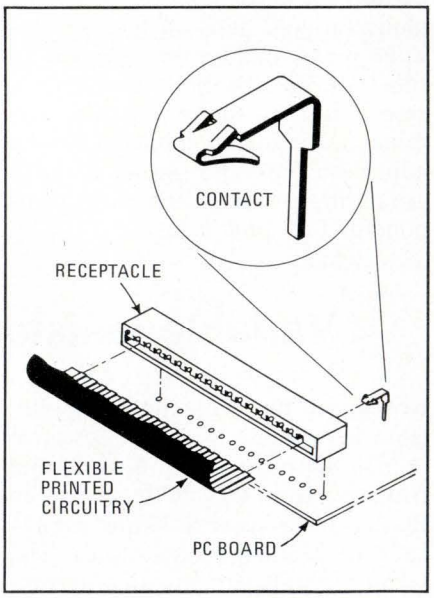
On other counts, flexible circuits and flat cables are excellent interconnection mediums. But none of the terminating methods used presently—soldering, mass bonding, crimping, pressure, welding—is completely satisfactory when it comes to matters of cost, ease of assembly, and reliability.

Flexlok, a new Burndy design based on its gold-free gas-tight high-pressure principle, is a low-cost, reliable series of connectors that are directly pluggable to flexible circuitry and flat cable without the use of special assembly, soldering, or welding equipment. In the Flexlok system, the spring force of a sharply pointed tip causes contact material to flow or extrude. This breaks down all tarnish and corrosion films, establishing metal-to-metal junctions.

A typical Flexlok connector and a expanded view of its special contact are shown in the figure. The contact, which is composed of a copper-alloy base plated with a tin alloy, engages the cable with a 150-to-200-gram pressure, eliminating the need for soldering.

Installation consists of wave-soldering the connector to a board and then going through a simple four-step cable-preparation procedure. This consists of stripping ¼ inch of insulation from both sides of the cable, folding the cable back on itself close to the strip line, tinning the exposed copper conductors, and plugging the cable into the connector. It is possible to skip the folding and tinning and still get a fairly good connection, but the four-step procedure is recommended for greater strength and lower contact resistance.

The connector series has a low profile (0.190 inch), narrow width (0.275 in. maximum), and contacts on 0.100-in. centers. The glass-filled nylon body will accept flexible circuits or flat cables from 0.005- to 0.015-in. thick having six to 21 traces. Electrical characteristics of



welcome addition to the family



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These TRW/Cinch Edge Connectors were created to beat rising material costs while maintaining product performance. Designed with 20 microinches of gold—at the contact areas only, over 30 microinches of nickel underplate—with high capability, glass-filled polyester insulators, they cost about 20% less than our standard commercial units, 50% less than our military types. The use of nickel, an effective barrier to base metal migration, rather than copper underplate, provides a longer wearing, more stable gold layer.

CC-7508

As with other members of TRW/Cinch Edge Connector family, you have a choice of seven sizes from 6 to 25 positions, in both dip solder and solder tab terminations—and delivery is when you expect it, from TRW/Cinch Connectors or its distributors.

For more information call your nearest sales office or distributor (listed in EEM)—or contact TRW/Cinch Connectors, An Electronic Components Division of TRW, Inc., 1501 Morse Avenue, Elk Grove Village, Illinois 60007, (312) 439-8800.

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ITHACO

New products

the connector are: 3-ampere current rating, −55°C to 65°C operating temperature, and a 15-milliohm (maximum) contact resistance.

Flexlok connectors have been tested, using military requirements, for vibration, shock, moisture resistance, and thermal shock. Moreover, samples of these units were exposed to an ammonium-sulfide atmosphere for 3 minutes with no evidence of corrosion, the company says. Under the same exposure, gold contacts reportedly became open-circuited.

Before this new connector, terminating flexible circuitry and cable cost from 3 to 15 cents per contact. In large volume, costs for the Flexlok system are about 1 cent per contact, partly due to the use of tin-plated contacts instead of the customary gold. However, manufacturing savings come about in several other ways for this plug-in system. For example, the method of termination does not require high-temperature cable material like Kapton. Instead, it uses polyester material, which is 1/20 the price. Connectors are supplied completely assembled, eliminating the need for special machinery, and there are no special assembly procedures.

So far, this mass-termination technique has mainly been used with flexible circuits (as part of the keyboard of a handheld calculator, for instance) and is presently being introduced into the flat-cable field. Burndy's engineers are working on longer versions of the new connector that provide the user with denser contact spacing.

Burndy Corp., Components Group, Norwalk, Conn. 06856 [408]

Bright switches

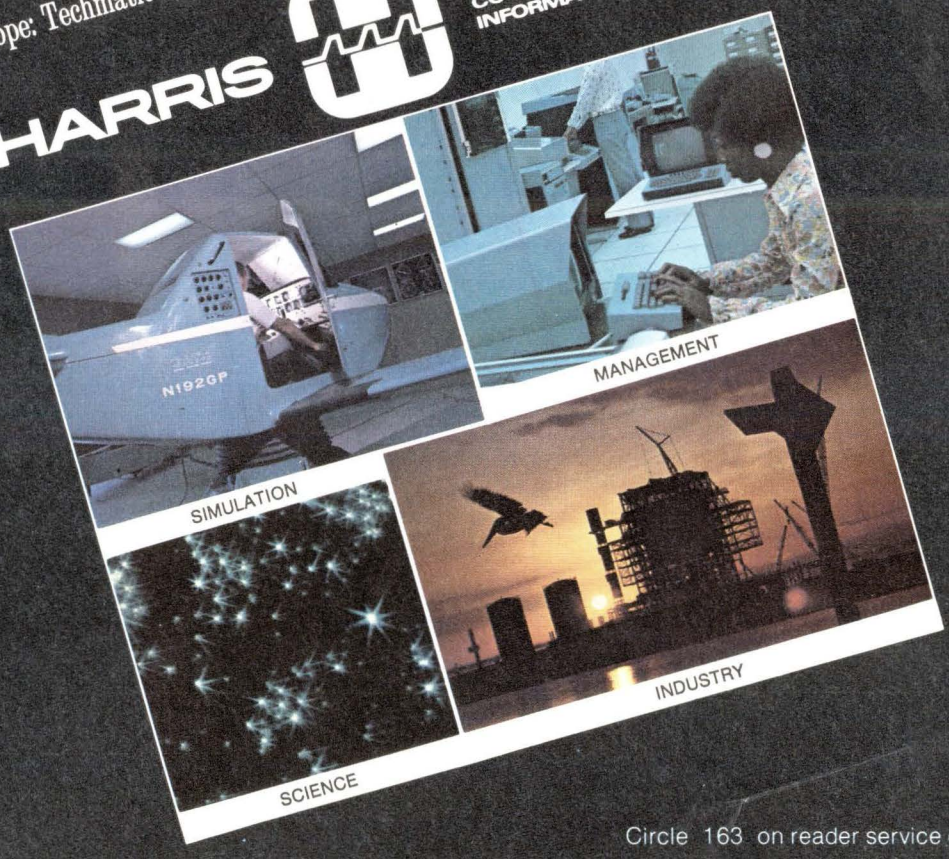
Hundreds of lighting and legend options are provided by a new line of lighted push-button switches intended for commercial, industrial, and military applications. These series PL units come in five colored push buttons (with either opaque or translucent backgrounds), seven col-

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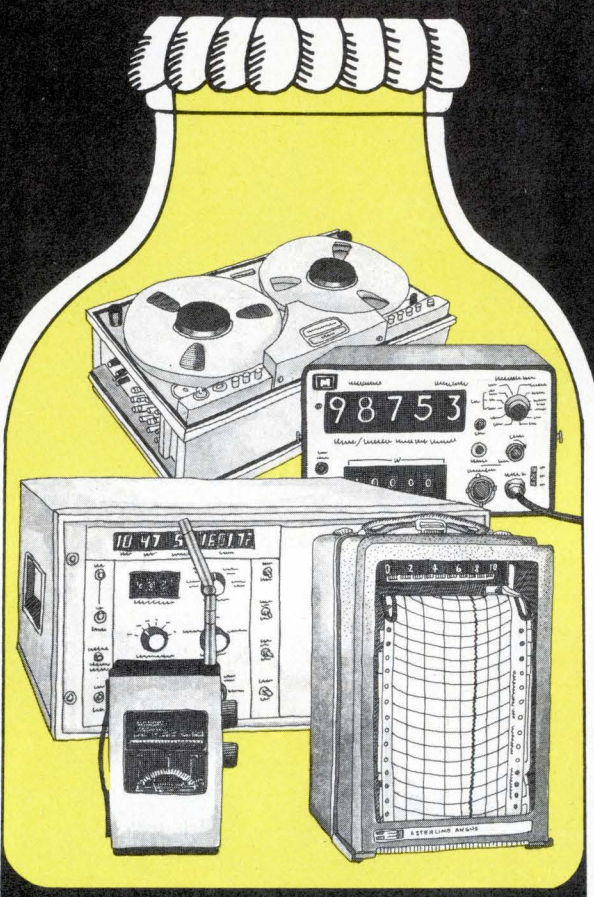
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Circle 163 on reader service card

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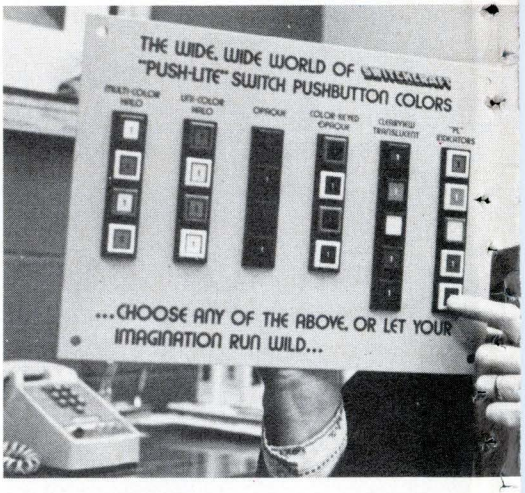
GENERAL ELECTRIC

ored screens, and also four colored filters.

Two types of display screens are available: one has a hot-stamped background that produces a clear legend; and the other has the legend and the border hot-stamped on a clear background. Four different push-button configurations can be produced by simply varying the type of screen being used.

The standard background color is opaque black, but translucent red, green, blue, white, orange, and yellow are available on special order. The housing colors are red, black, green, white, and yellow.

The switches are available in both momentary-action and push-to-



lock/push-to-release versions. For a noninductive load, contact ratings for single-pole double-throw and double-pole double-throw units are 2 amperes root-mean-square at 200 watts maximum, 5 A rms at 250 V max, or 8 A rms at 125 V max. A four-pole double-throw unit can also be supplied.

These PL pushbuttons can be purchased individually from stock at a typical cost of 50¢ in lots of a hundred. They are also being offered in style kits containing a selection of buttons, filters, and display screens.

Switchcraft Inc., 5555 North Elston Ave., Chicago, Ill. 60630 [409]

This product preview was prepared by Lucinda Mattera, Components Editor, assisted by Jerry Lyman, Packaging & Production Editor, and Michael J. Riezenman, New Products Editor.

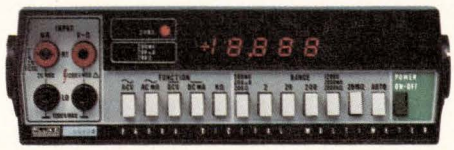


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Five-range AC/DC volts to 1200V											●
Five-range AC/DC current to 2A			●						●		●
Six-range resistance to 20 megohms					●			●	●		●
Autorange through all ranges plus individual range selection manually									●		●
10,000 Hour demonstrated MTBF											●
Continuous overload specified for all ranges/functions with overload indication								●		●	●
Environmental capability specified and defined											●
Automatic zeroing	●	●				●	●				●
Full line of accessories offering HI volts to 40 KV, RF to 500 MHz, current to 600A											●
Rechargeable battery option, completely built-in and self-contained				●		●	●		●		●
7W or less power consumption for reliability								●			●
Basic DC accuracy of 0.02% for 90 days at 15° C to 35° C	●										●

Ten companies claim to offer a 4½ digit multimeter competitive to the Fluke 8600A. As you can see from the truth table, no one measures up to Fluke. Some have more features than others. None have all the fine features of the Fluke 8600A. For a modest $649 (U.S. price), you can put the 8600A to work right away.



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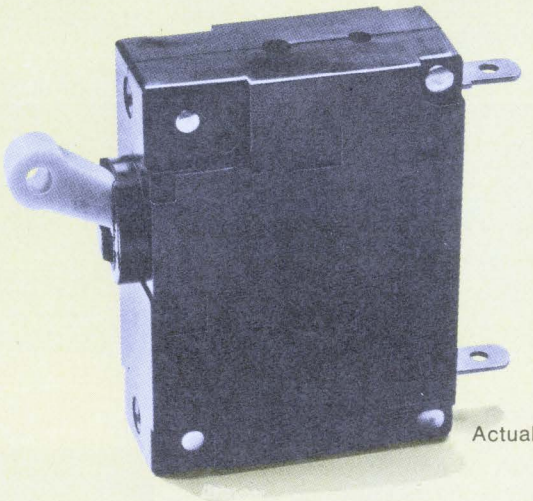
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Actual Size

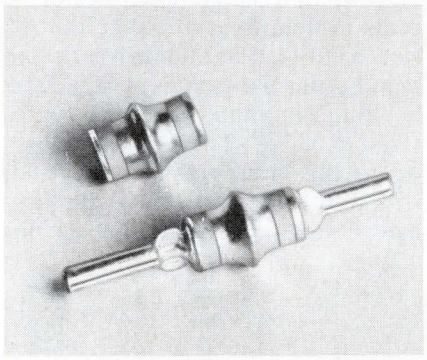
Circle 166 on reader service card

Components

Feed-through capacitor is tiny

Device for television tuners has diameter of 0.2 inch, is 0.25 in. long

The television industry's trend toward smaller tuners with all-detent switching for the uhf as well as the vhf bands has created a demand for a low-cost miniature feed-through capacitor with all of the



quality of a standard-size unit. Centralab's response to this demand is its FH80/FH81 family—a line of capacitors with a maximum outside diameter of 0.2 inch and a length of 0.25 inch ±0.01 in.

The company plans to offer the capacitors in a range of values from 2.2 picofarads to 3,000 pF, but, at present, only the 1,000-pF value is ready for delivery.

The capacitors come in three different tolerances: ±10%, ±20%, and guaranteed minimum value. They have a working voltage of 300 V dc, a dielectric strength of 750 V dc, and a minimum insulation resistance of 7,500 megohms at 300 V dc. Their operating temperature range is −55 to 85°C.

The FH80 is a leadless device while the FH81 has quarter-inch leads of solder-coated 15-gage wire. The devices can be reflow-soldered at a maximum temperature of 450°F for a maximum of 5 seconds.

In addition to their small size, the miniature capacitors have two other physical characteristics that make for ease of assembly. Their mounting flange, being an integral part of the case, both reduces the number of parts that must be handled during assembly and makes the mounted capacitor much less likely to become loose under vibration. The second property is the symmetry of the case design: the capacitors can be mounted either way. Most others must be oriented into the proper direction before they can be fastened to a chassis or bulkhead.

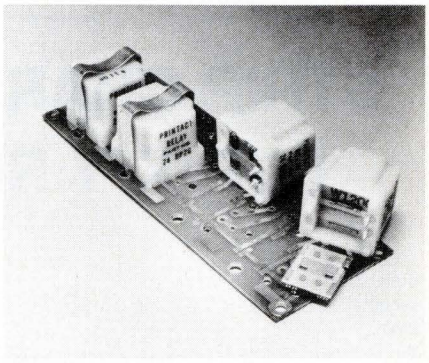
In OEM quantities, the 1,000-pF FH81 has a per-thousand price of $21, while the leadless FH80 sells for $19 per thousand.

Centralab Electronics Div., Globe-Union Inc., 5757 North Green Bay Ave., Milwaukee, Wis. 53201 [341]

Circuit-board relays switch at 100 milliwatts

Because the movement of the contact assembly is guided, a series of printed-circuit-board relays can operate when driven by only 100 milliwatts. The guiding is done by plastic bosses on the walls of the encapsulated coil housing. The design not only eliminates friction at the guide pads on the housing but also reduces the reluctance at the hinge, resulting in good operating sensitivity.

The series BW2-GS relays, which measure 0.896 by 0.920 by 1.032 inches, are available in a variety of coil resistances, from 4 to 4,800 ohms. The series-break swinger-blade contact assembly mates directly with the conductors on a pc board, permitting the board to be laid out for either isolated or common switching between closed and open contacts. Each of the two contact blades can function as both Form A and Form B arrangements (isolated from each other), or as a Form C arrangement (with a common connection between the normally open and normally closed contacts). Maximum contact rating



of the relays is 1 ampere at 24 volts dc.

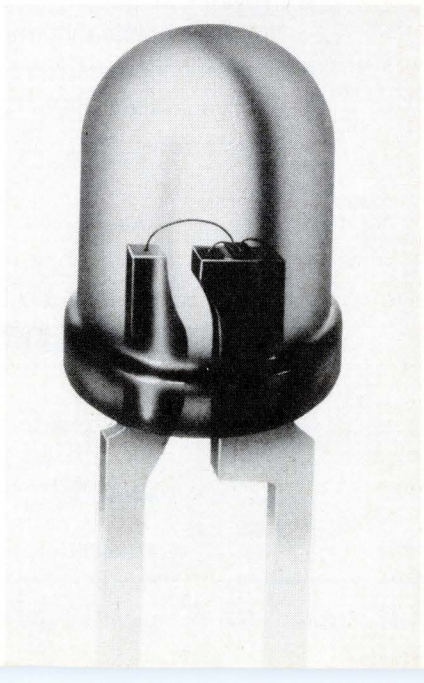
The devices can be plugged into a pc board directly, without soldering or the need for sockets. Contact bounce and contact resistance are low, and operating times are fast.

In quantities of 1 to 24, units with coil resistances of up to 1,200 ohms are priced at $4.54 each. Delivery time is four to six weeks.

Executone Inc., Printact Relay Div., 29-10 Thomson Ave., Long Island City, N.Y. 11101 [342]

LED lamp has very sharp, stable turn-on threshold

Intended for use as a built-in battery tester for such items as cameras, radios, and portable test instruments, the HP 5082-4732 voltage-sensing lamp snaps on sharply when a voltage of 2.5 V ±10 millivolts is applied. The device consists of a

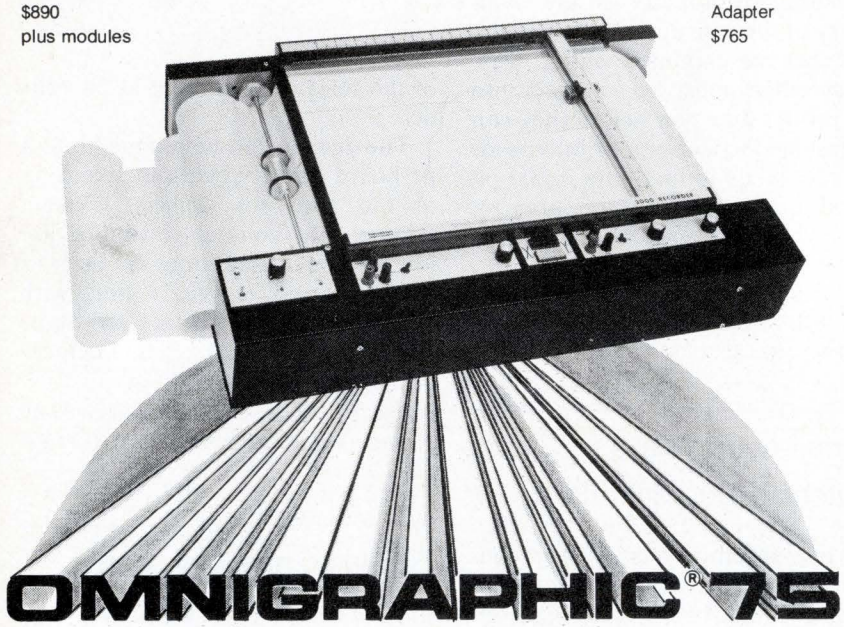


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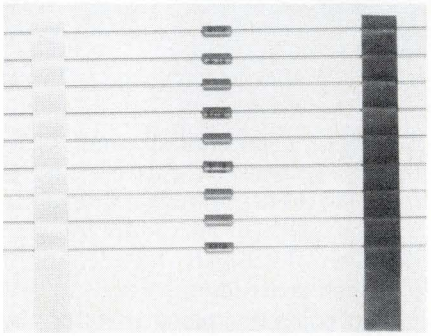
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temperature-compensated gallium-arsenide-phosphide lamp and a one-chip integrated circuit mounted in a standard T-1 lamp package. To achieve turn-on voltages higher than 2.5 v, one need only add an external zener diode or resistor to the voltage-sensing-lamp circuit. The price of the 5082-4732 is 68 cents in thousands; delivery is from stock.
Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [343]

Metal-can solid-tantalum capacitor is 20 cents

Having an average unit price of 20 cents in quantities of 5,000, the AT (for axial-lead tantalum) series of metal-can, solid-tantalum capacitors is offered in values from 0.1 microfarad to 680 μF. The devices have an operating temperature range of −55°C to 85°C, and come with voltage ratings from 3 to 35 v dc. In-



tended for such applications as calculators, paging systems, hearing aids, television, and stereo systems, the AT series can be lead-taped and is suitable for handling by automatic-insertion or lead-forming machinery.
International Components Corp., 105 Maxess Rd., Melville, N. Y. 11746 [345]

Tantalum-film resistors are priced as low as 5 cents

A family of tantalum-film resistors with tolerances of 1%, 2%, and 5% is offered in values from 10 ohms to

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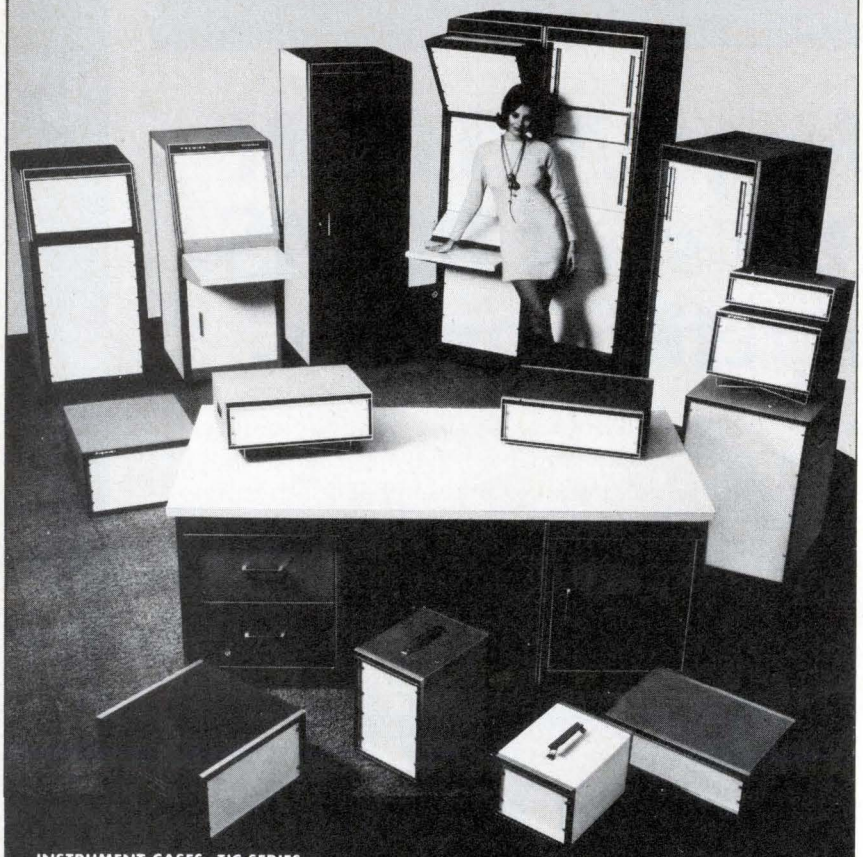
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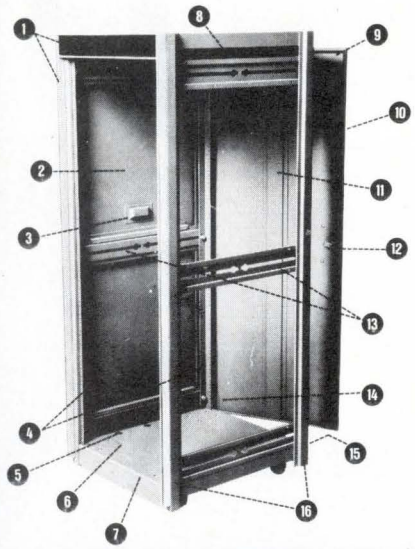
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3. Recessed hand grip for panel removal
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10. Magnetic closure gasket
11. Door stiffener channel
12. Keyed latch and brushed aluminum pull handle
13. Horizontal cross-brace and panel mounting angle supports
14. Quick release, spring loaded door hinges (top and bottom)
15. 1⅛" dia. knock-outs for rear cable entry underneath rear door
16. Formed steel uprights (14 ga.) provide ½" recess to panel mounting angles

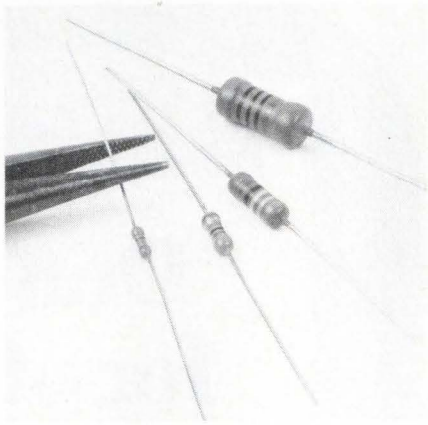
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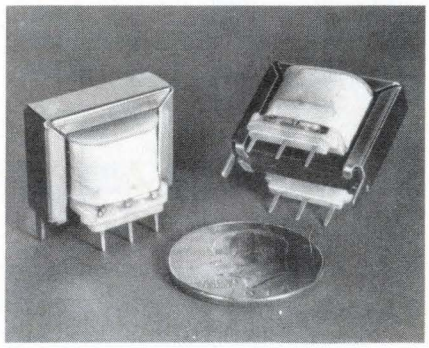


1.5 megohms. Designated type RTL, the Hokuriku Electric Industry Co. (HDK) resistors conform to MIL-R-22684B and are suitable for consumer and industrial electronic products. The resistors are available in four power ratings: 0.25, 0.5, 1, and 2 watts. The highly stable devices are fabricated by a patented process in which a tantalum film is sputtered onto a cylindrical ceramic substrate. Pricing on the resistors is as low as 5 cents apiece for certain 0.25-watt units.

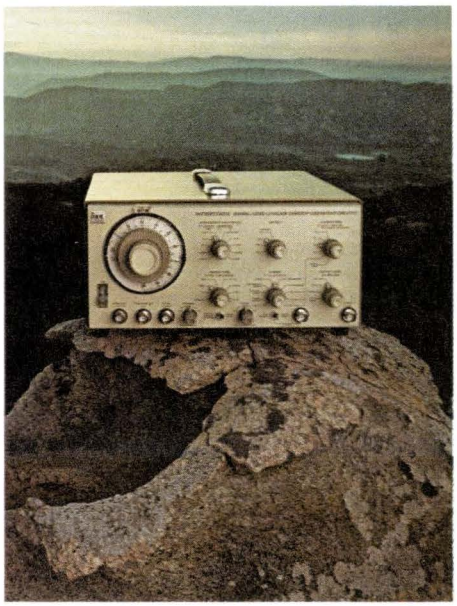
International Importers Inc., 2242 South Western Ave., Chicago, Ill. 60608 [344]

Low-power transformers may be connected in parallel

Rated at 1.5 watts, the PL-22 Series of power transformers may have its secondaries connected in series or in parallel for doubled voltage or current. Designed for mounting on printed-circuit boards, the dual-primary units can work with input voltages of either 115 volts at 60 Hz or 230 V at 50 to 60 Hz. Seventeen



Why you can afford the very finest in function generators.



Because Interstate's new F77 truly is a universal signal source. With F77's 0.00002 Hz to 20 MHz range, you can test with frequencies from infrasonics through video, and beyond. There are 6 output waveforms, 7 operating modes, and precision interface controls (waveform inversion and a 5/95% waveform variable symmetry vernier, for example) that can be actuated with remarkable variations. And output amplitude is specified at 15 volts p-p into 50 ohms — that's 50% more voltage swing than most 20 MHz function generators provide.

Because the F77 also incorporates a very capable, independent sweep generator offering linear and logarithmic performance, with a selection of auxiliary outputs. Sweep up or down, sweep reset control, and continuous, triggered, burst, sweep-and-hold modes, too. Interstate's special frequency dial has a direct-reading sweep limit cursor, plus two calibration scales (X1 and X2) to improve resolution and permit continuous tuning across the 20 Hz-to-20 KHz audio band.

Because this function generator is the first of its kind to deliver real pulse generator capability. The F77 produces a 15 ns rise time pulse to 20 MHz with constant width setability from 30 ns to 10 milliseconds, and full offset and mode flexibility. The generator's fully-calibrated attenuator gives you 15-volt unipolar pulses into high impedance loads, particularly useful for testing MOS, or millivolt pulses down to 1.5 mv.

Because there's also a constant duty cycle pulse (in addition to F77's standard pulse) for a variety of digital signal response applications. Circuit sensitivity to duty cycle on/off times can be tested using varying pulse rates without adjusting the width control.

Because the F77 can be used as an analog power amplifier to amplify externally applied signals as much as 600%. Even TTL pulses can be amplified to drive 50-ohm loads, and the resulting output has controlled dc offset and attenuation.

Because the F77 gives you many other high performance and human engineering features, like VCF capability for sweeping frequency-sensitive devices, and "oscilloscope-style" triggering with a variable start-stop phase control to generate haversines and havertriangles. There's even a "brown-out" switch to allow the instrument to operate at low line voltages.

Because the F77 only costs $1,095.*

*U.S. price; other 20 MHz Series 70 models available from $695.

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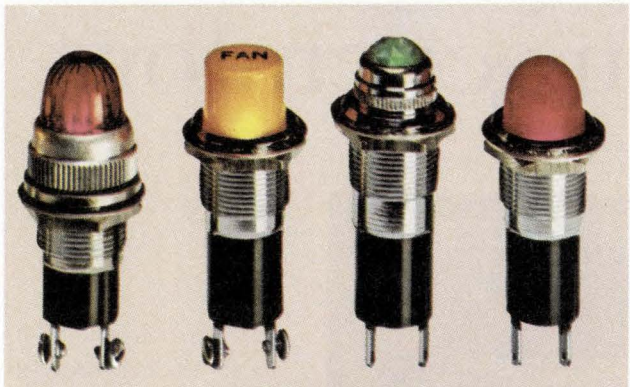
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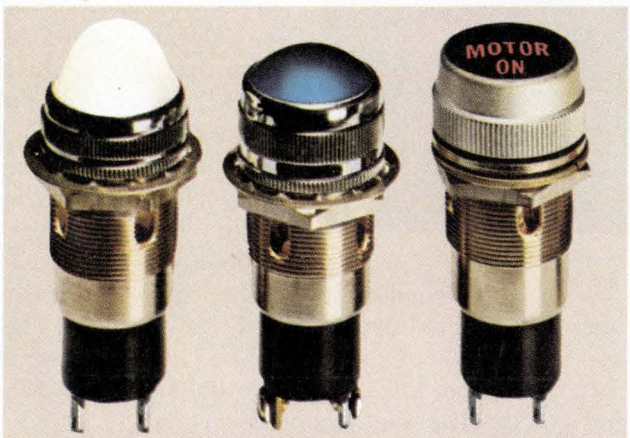
Circle 171 on reader service card

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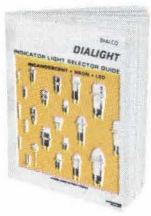
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New products

standard models are offered. Price of the PL-22 series is $2.75 each in large quantities.

Dale Electronics Inc., East Highway 50, Yankton, S. D. 57078 [346]

Touch-activated switches have no moving parts

Available in both illuminated and nonilluminated versions, a line of touch-activated switches has no moving parts. As a result, the switches have no contact bounce and no mechanical-wear failures. At the touch of a finger, the switches, which are essentially proximity detectors, put out a 2-microsecond pulse train at a rate determined by a system clock. The pulses can interface directly with various standard logic families. Illuminated versions of the switches contain LED lamps in a choice of three colors: red, green, and amber. A spring-clip allows mounting through a front-panel cutout. The switches sell for $1.90 each in large quantities.

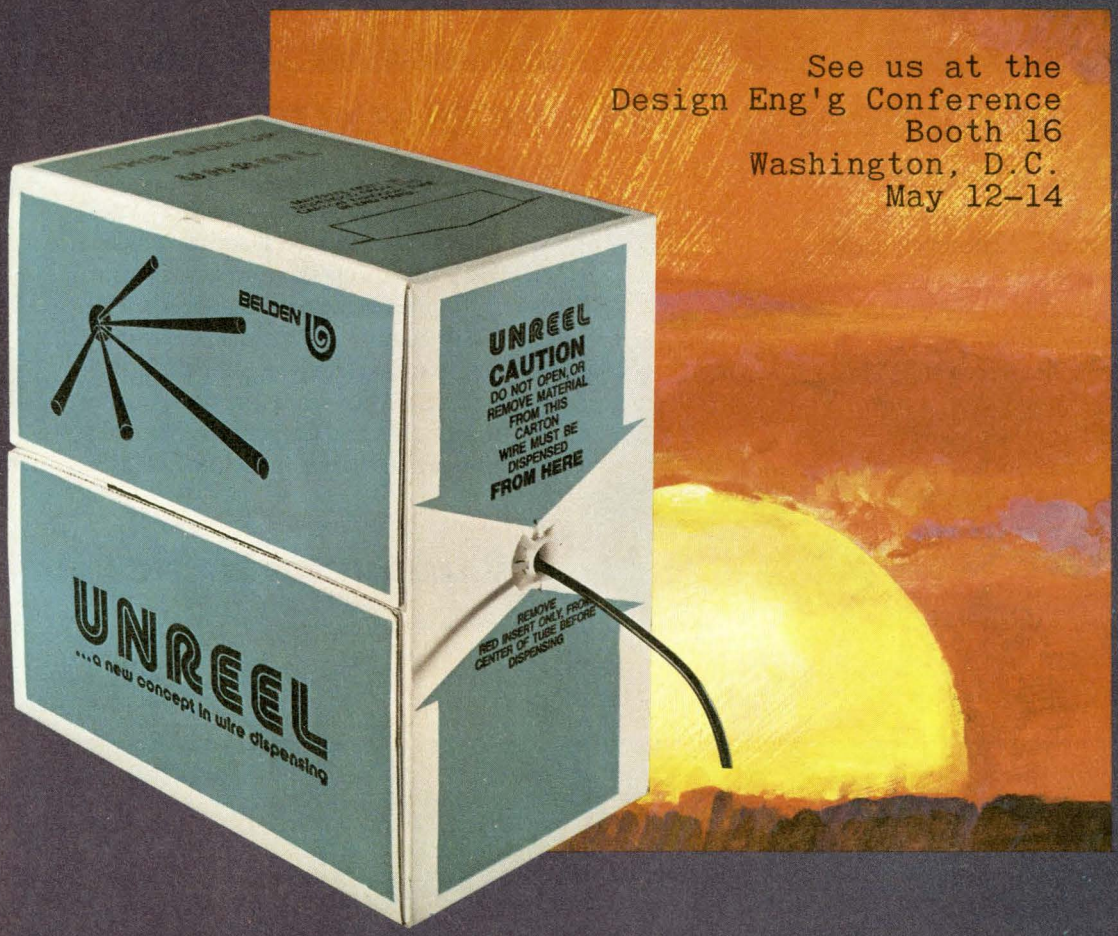
Master Specialties Co., 1640 Monrovia Ave., Costa Mesa, Calif. 92627 [347]

Surface-acoustic-wave delay lines are phase coded

A line of phase-coded delay lines that employs surface-acoustic-wave technology is intended for applications such as bit synchronization in data communications, spread-spectrum radar and radio work, and other military and commercial uses. The devices are offered in the 10- to 200-megahertz range with standard codes such as the Barker code, or with any biphase or quadriphase code specified by the customer. The model BC 30-3-13 is encoded in a 13-chip Barker sequence; it has a small-quantity price of $350 each, and delivery time is from stock to 60 days. Prices of other units will depend upon customer coding and environmental requirements.

Andersen Laboratories Inc., 1280 Blue Hills Ave., Bloomfield, Conn. 06002 [348]

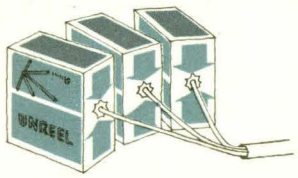
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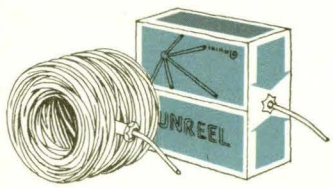
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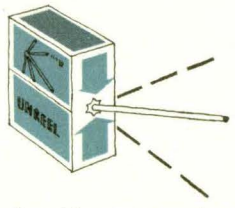
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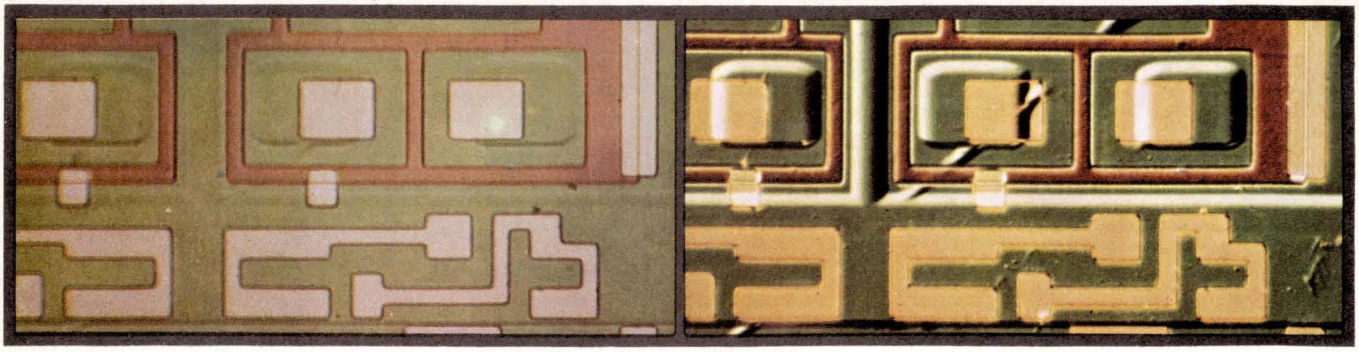


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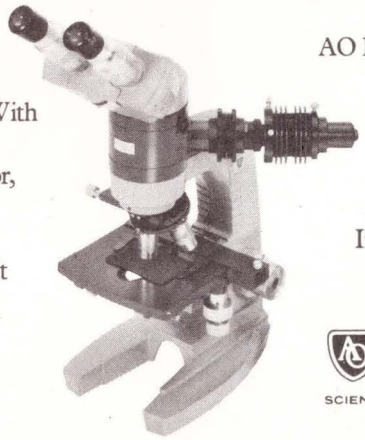


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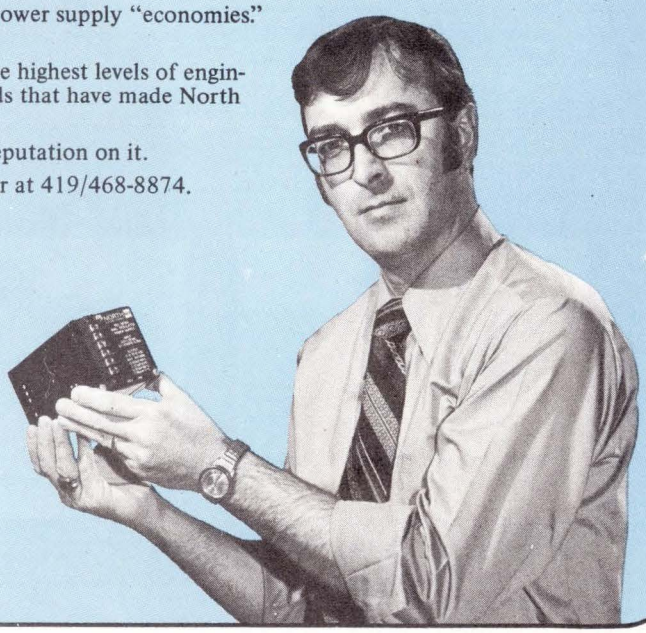
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VDC	AMPERES							
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12.0	2.8	4.2	8.0	10.5	15.0	23.0	36.0	58.0
15.0	2.4	3.7	7.5	9.5	14.0	20.5	27.0	47.0
18.0	2.1	3.3	6.0	8.0	13.0	18.0	26.0	40.0
24.0	1.5	2.8	4.2	7.0	11.0	15.0	21.0	33.0
28.0	1.4	2.4	4.0	6.3	9.0	14.0	20.0	29.0
36.0	1.2	2.2	3.1	5.6	8.0	11.0	14.0	23.0
48.0	.95	1.8	2.6	4.2	6.0	8.0	10.0	18.0

DUAL OUTPUT SUPPLIES	
MODEL	N03052
VDC	AMPS
±15-12	400MA
MODEL	N60052
VDC	AMPS
±15-12	1.0A

MODEL	10000
VDC	AMPS
0–7.5	2.10
0–16	1.25
0–25	0.85
0–33	0.68

Listed here are the more popular models-many other voltages are available.



NORTH NEC ELECTRIC COMPANY

North Electric Company / Galion, Ohio 44833 / A United Telecom Co.

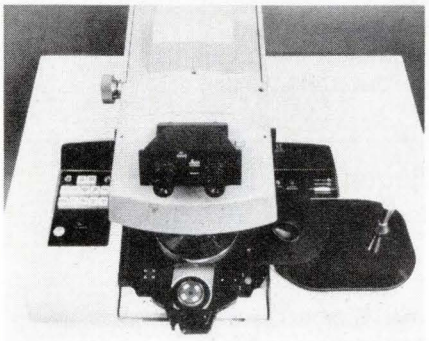
SP-18

Packaging & production

Aligning wafers with precision

Mask-positioning, exposure system offers high resolution, repeatability

As the semiconductor industry moves into pilot production of extremely small devices (in the submicrometer range), geometries are important, and fabrication-equipment makers are hard-pressed to come up



with hardware of the requisite accuracy and resolution.

Most existing mask-alignment and exposure systems, for example, can resolve down to the 0.25 and 0.5 micrometer necessary in the fabrication of microwave transistors, magnetic-bubble memories, integrated injection-logic circuits, surface-wave devices and charge-coupled devices. But moving a wafer in the even smaller steps necessary to align it in a repeatable, production-mode fashion is in most cases out of the question. An unusually experienced and talented human operator may on occasion move the wafer in the submicrometer steps, but not without many yield-reducing contacts between the mask and the wafer.

Now, Cobilt, a division of Computervision Corp., is introducing a new mask-alignment and exposure system—the model CA-2020—which combines semiautomatic submicrometer operation with an ultra-low-force mask-wafer contact technique that solves both these problems. Features include motorized operation for independently controlling motion in the X and Y axes, notation, and a dual-focus optical system that allows sharp-focus viewing of the mask and the wafer when separated by a distance of 1 to 2 mils. This reduces optical mask damage caused by trial-and-error contact.

The motorized X-Y motion is controlled by the manipulation of a seven-position joystick with single-step capability down to 0.125 micrometer. Three push buttons on the control panel adjust rotational positioning. Range is ±4,000 steps, equal to ±20 mils. The viewing optics, corrected for 60-mil mask thickness, are a high-magnification split-field system, fully compensated for inter-objective spacing. The objective lenses are independently adjustable. Magnification is 300× and 600×. Resolution is better than 1 micrometer.

To reduce mask damage, the "microforce" feature of Cobilt's model CA-800 aligner has been incorporated into the CA-2020. In the conventional in-contact mode, the mask/wafer contact force is typically 5,000 to 20,000 grams. With the microforce feature, the 2020 can make adjustments within a 9-to-182-gram range.

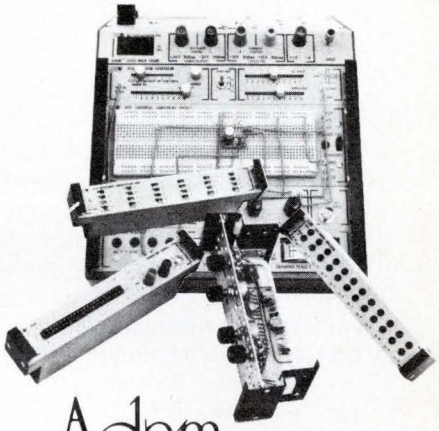
The system is priced at $32,000.

Cobilt, Division of Computervision Corp., 2727 Augustine Dr., Santa Clara, Calif. 95051 [391]

Portable wire welder sells for $495, weighs 10 lb

Although welded-wire equipment has been around for quite a while, the technique has not been widely used because welders have been both expensive and non-portable. Now the advantages of wire welding—high-density wiring, rapid prototype development, good high-frequency characteristics, and ease of circuit modification—can be obtained in a machine that sells for $495 in unit quantities, measures 8

If you Created A New World of Circuit Design Equipment, What would you name its first Citizen?



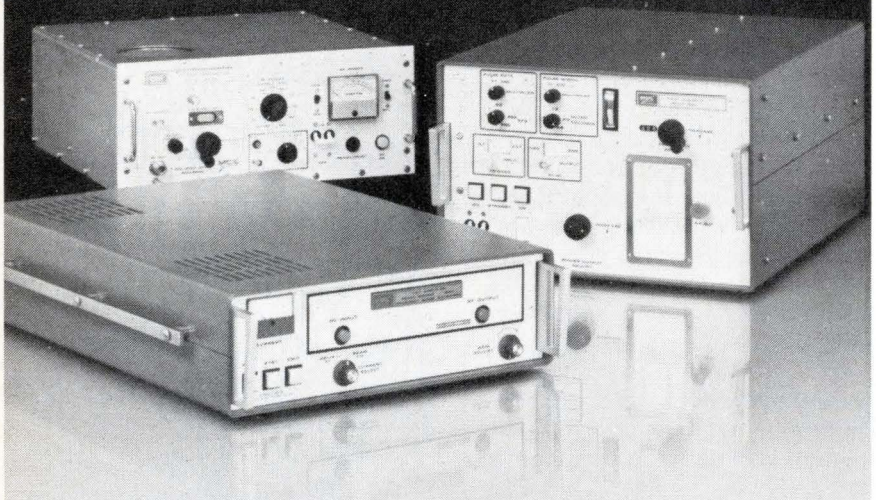
Adam... of course.

Adam is indeed a new generation of circuit design and breadboarding equipment. Its modular concept allows many engineers to use the same mainframe and instrument modules concurrently. The recent addition of the resistance substitution, connector, digital indicator, and universal instrument modules, along with the function/pulse generator, socket, signal source, and readout modules, give you an unbeatable package.

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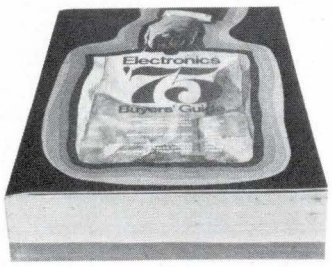
Circle 176 on reader service card

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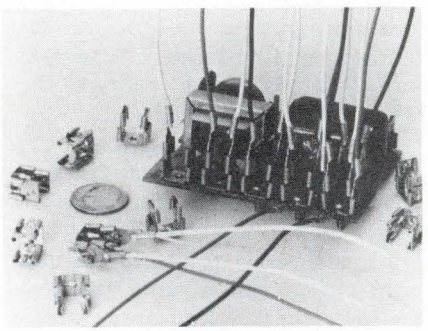
by 13 by 11 inches, and weighs about 10 pounds.

Intended to provide an alternative to the wrapped-wire technique of circuit interconnection, the Wire*Bonder, can work with terminals spaced on 0.1-inch centers and measuring less than 0.125 inch on the wiring side of the board. The wires it uses do not have to be cut and stripped, making assembly both fast and easy. Wiring can easily be changed by simply clipping off the unwanted wires and bonding new ones where desired. In short, the Wire*Bonder attempts to combine the density and electrical characteristics of multilayer printed-circuit boards with the changeability and ease of design of wrapped-wire assemblies.

3G Co., Inc., 37a Williams Canyon Rd., Gaston, Ore. 97119 [393]

Receptacle can handle five connections on one terminal

A receptacle called the Quad Tabon, that accepts up to five spade lugs—four on the terminal body itself, and one on its mounting screw—offers the user the advantages of high-density interconnections on printed-circuit boards. Intended primarily for low-voltage boards such as are used in telephone and other telecommunications equipment, the Quad Tabon accepts four spade terminals that measure 0.250 inch wide by 0.016 inch thick. The fifth interconnection can be made either with an additional spade lug or with a stripped wire. The Quad Tabon is priced at $9.25 per 1,000 in quantities of



For measurement, control and data processing

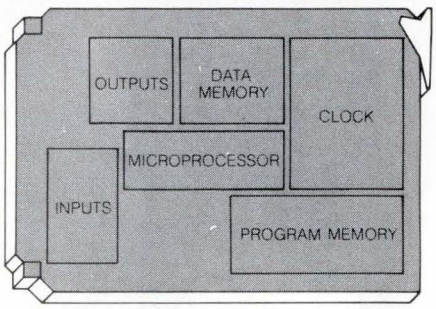
Microprocessor modules cut design time, production costs by up to 80%

Pro-Log's microprocessor modules are the hottest item around for use in dedicated control and data processing applications.

What is a microprocessor module?

By using large scale integration, a number of semiconductor manufacturers have made chips containing the central processor units used in small computers. These chips are called microprocessors.

Pro-Log has taken these microprocessors and coupled them with memory, a clock, and flexible input/output circuitry to produce a unique device called a microprocessor module.



Where can it be used?

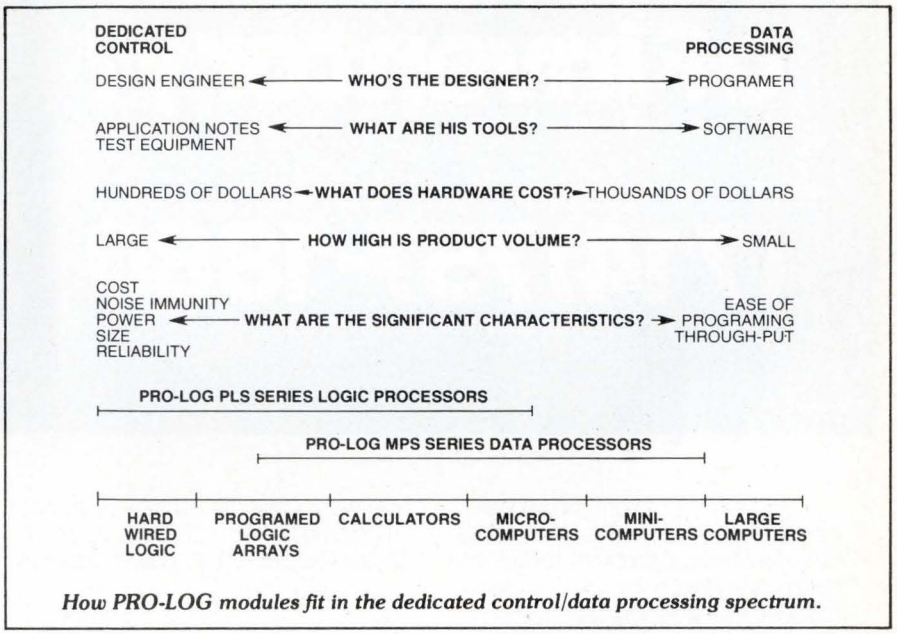
Microprocessor modules can be used in two general areas, dedicated control and data processing.

The dedicated control function is now being largely performed by hard-wired logic. Examples include calculators, pinball and slot machines, electronic cash registers and scales, test equipment, stoplights, medical monitoring systems, machine and process controllers . . . in fact almost any situation in which a man interfaces with a machine.

Data Processing applications are now most often handled by computers. Examples include record handling, accounting, inventory control, scientific analysis . . . wherever large volumes of varying data have to be manipulated and evaluated.

How it saves time and money

A microprocessor and a programed PROM working in unison can replace large numbers of logic gates and timing elements. This also eliminates the sockets, power supplies, packaging, connectors, and wiring associated with hardwired logic. By decreasing the number of parts and interconnections in your product, you lower assembly and rework costs, improve reliability and cut inventory, making microprocessor modules a real cost-effective method of performing dedicated control and data processing. As a rule of thumb, if your circuit design calls for the use of more than 50 chips, a microprocessor module can probably do the job for less money.



How PRO-LOG modules fit in the dedicated control/data processing spectrum.

Since microprocessor modules are relatively simple, service calls become less expensive. And you spend less money and time in educating service engineers in system repair.

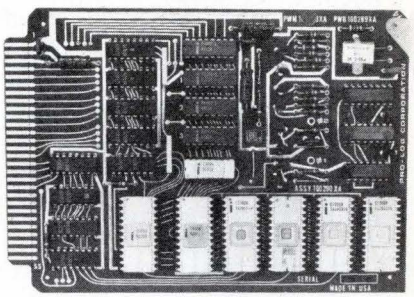
With our microprocessor modules, and test equipment, there's no need for design engineers to learn traditional programing techniques. It's not necessary to use assemblers, simulators, or compilers to arrive at working hardware.

Through the use of microprocessor modules, most companies realize savings of 60% to 80% over old-style designs.

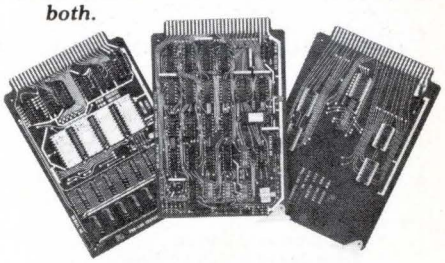
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- **Application notes.**
- **Designer manuals.**

For product information, circle number 215.
For information on applications courses circle number 216.
For information on design courses circle number 217.



Shown above: Pro-Log's PLS-401 microprocessor module for dedicated control. Price $355.
Shown below: Pro-Log's MPS-803-1 microprocessor modules for data processing. Price $810.
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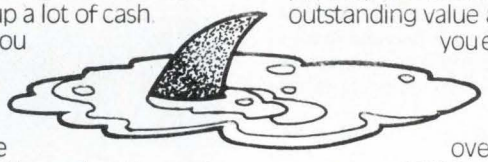
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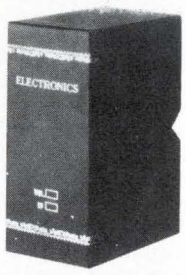
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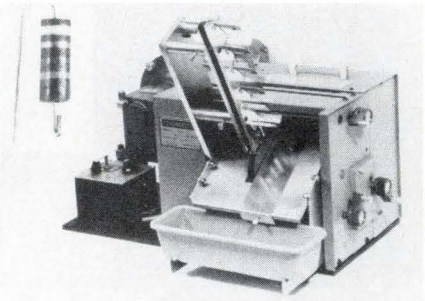
City: State: Zip:

500,000 pieces. Delivery is stock to four weeks.

Malco, a Microdot Company, 5150 W. Roosevelt Rd., Chicago, Ill. 60650 [394]

Lead-forming machine improves reliability

The Leadmaster H-113 is an axial-component lead-forming machine that automatically provides a folded-back, double-diameter, wedge-shaped lead on components that are to be inserted vertically into printed-circuit boards. This new lead form enhances the reliability of the soldering process in two ways:



the firm wedging of the leads in the pc-board hole eliminates rocking and floating, and the solder-inhibiting oxide coating on the leads is broken down by the coining action of the machine. The Leadmaster H-113, including all necessary tooling, sells for $3,995.

Heller Industries Inc., 18 Microlab Rd., Livingston, N. J. 07039 [395]

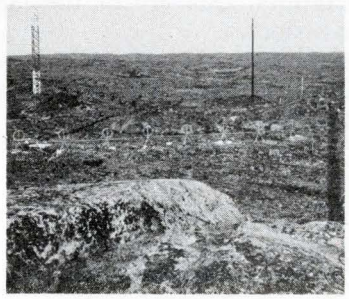
Self-aligning bearings double life of low-cost fans

A family of small cooling fans designated the Series 390 "Brute" incorporates a self-aligning, permanently lubricated bearing system that is expected to extend sleeve-bearing fan life beyond 10 years. The life expectancy of conventional concentric-motor sleeve-bearing cooling fans, by contrast, is about five years in most applications. Available in 24 models and two sizes—4.5-inch and 3.125-inch

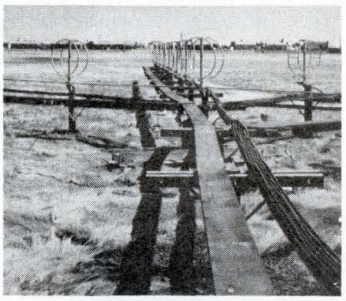
HERMES LOOP ANTENNA

THREE SAMPLE SITES ON THE NORTH AMERICAN CONTINENT —

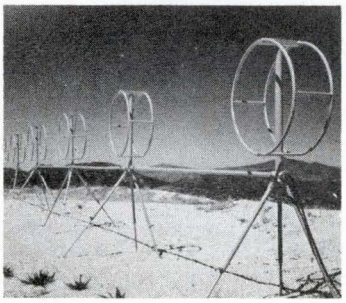
DIFFERENT LATITUDES
DIFFERENT CLIMATE



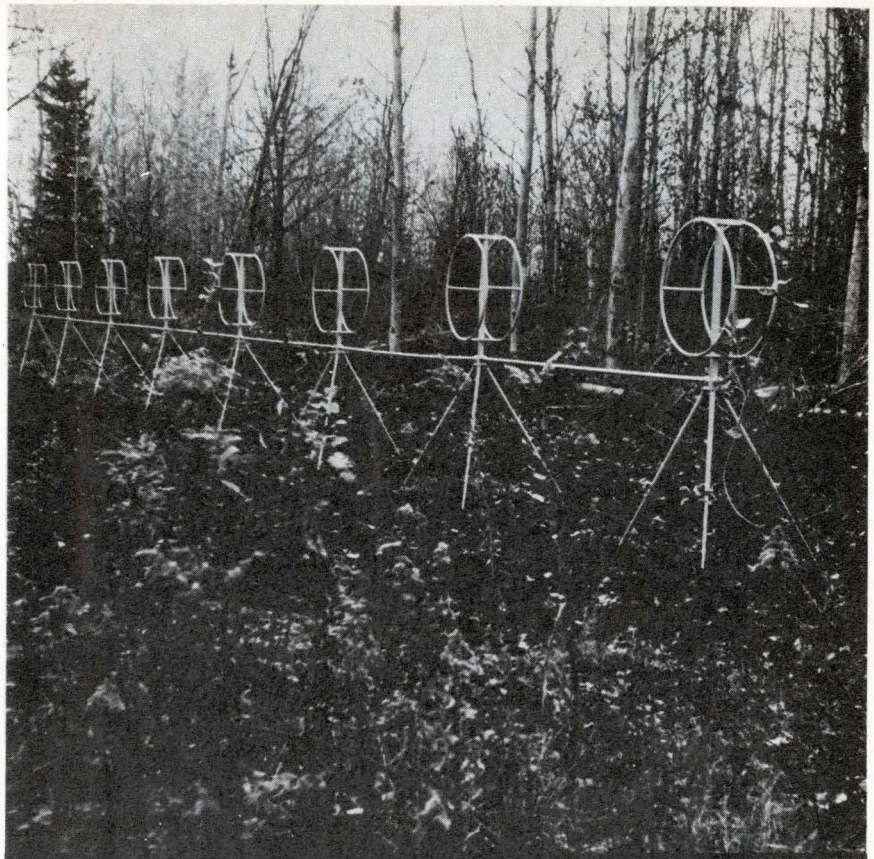
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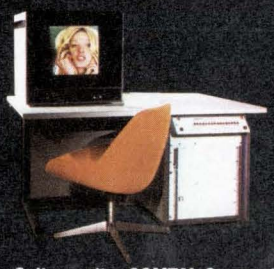
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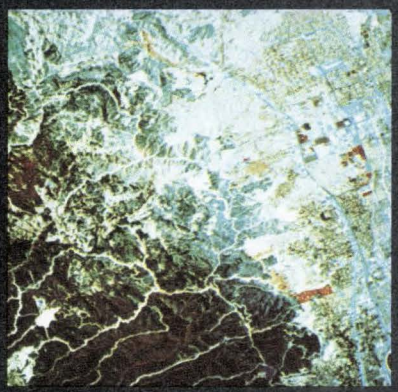
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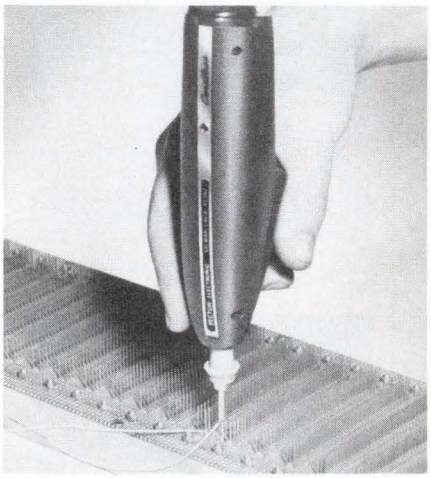
New products

square configurations—the series 390 units are said to be between $2 and $3 cheaper than conventional fans. The fans' extended life is attributed to an oil recirculation system in which spiral grooves on the fan shaft pump lubricant from the bearing-shaft interface to a reservoir. In addition to longer life, the Brute fans typically deliver more air per minute than comparable competitive units. The standard 4.5-inch unit sells for $5.90 in lots of 1,000 pieces, while the 3.125-in. "mini Brute" is priced at $4.70 in similar quantities. Delivery of the fans is from stock.

Amphenol Sales Div., Component Marketing Service, 2875 South 25 Ave., Broadview, Ill. 60153 [396]

Battery-powered wire-wrap tool sells for $59.69

Designed for prototype or low-volume production, a rechargeable, battery-operated wrapped-wire tool

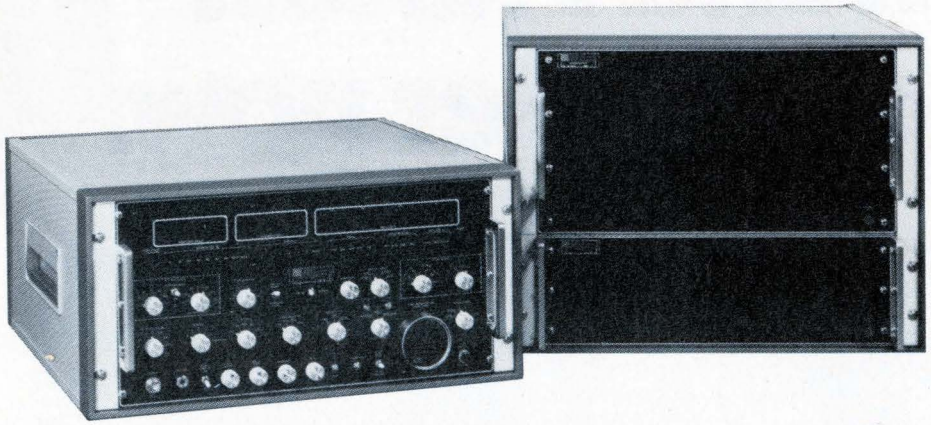


is priced at $59.69 including wrapping bit, line cord, and recharging unit. The tool weighs only nine ounces, and can handle 26- to 30-gauge wire. Its Ni-Cad batteries have a nominal operating time of eight hours between charges. Recharging time is 14 to 16 hours, the company says. The P160-4 tool and P160-2 bit are available from stock.

Vector Electronic Co. Inc., 12460 Gladstone Ave., Sylmar, Calif. 91342 [397]

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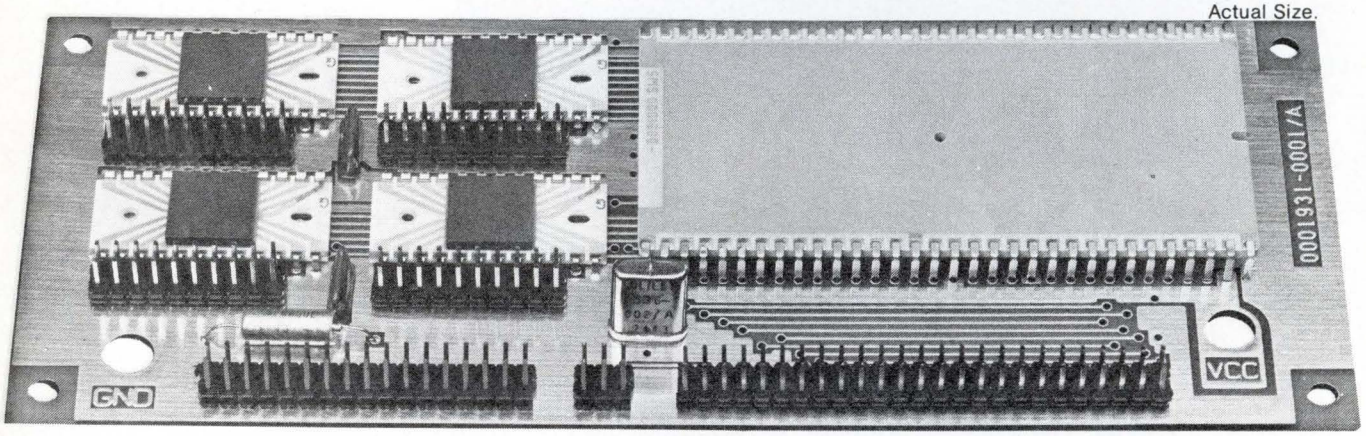
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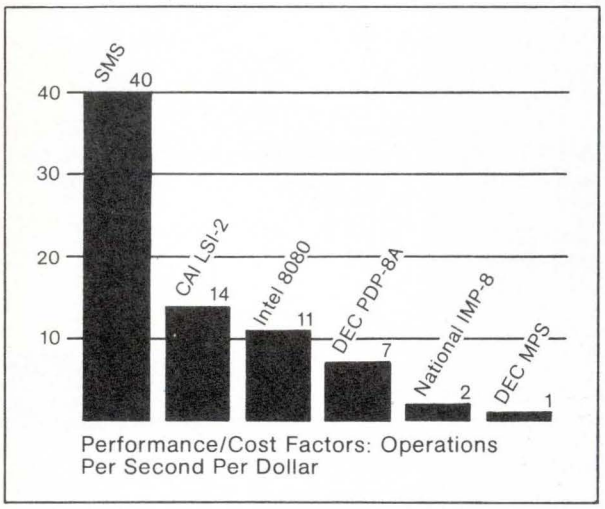
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How it stacks up.



*Quantities of 100. Basic system shown includes CPU, 512 words of program storage (ROM) and 32 I/O points (4 parallel byte interfaces). Completely assembled and tested on a single PC board. Performance/Cost chart based on independently defined benchmarks; details available on request.

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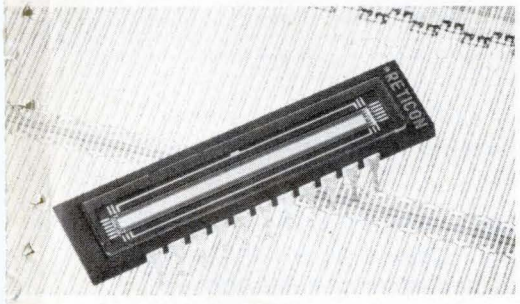
Circle 182 on reader service card

Semiconductors

Imaging arrays are solid-state

Reticon scanner uses MOS photodiodes; Fairchild's is charge-coupled device

Using two different technologies, two different companies are introducing solid-state line scanners designed primarily for page reader and facsimile applications. Reticon Corp.'s device has 1,872 elements,



and Fairchild Semiconductor's has 1,728 elements.

Reticon's scanner, the RL-1872F (above), is a monolithic silicon metal-oxide-semiconductor array of 1,872 photodiodes. The diodes are in a row with a center-to-center spacing of 15 micrometers or 0.59 mil.

Each diode has an associated capacitance on which photocurrent is integrated until it is read out periodically through a multiplex switch onto one of four video output lines. The diodes are read out by a shift-register scanning circuit which is driven by four phase clocks. Each scan starts when a start pulse enters the shift register. On each clock transition during a scan, two adjacent diodes are read out simultaneously. Once the last pair of diodes has been read out, a new scan may be started immediately or a longer interval between start pulses may be used to increase integration time.

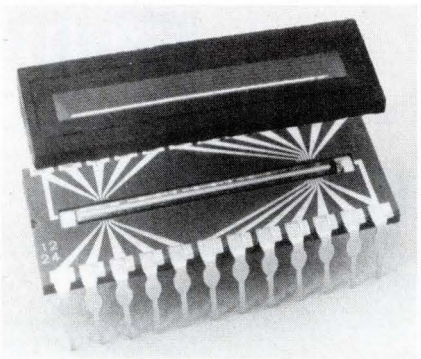
The device can be operated at sample rates as high as 20 megahertz, corresponding to line rates up to 10 kilohertz. This means an 8½-inch-wide page can be read in a fraction of a second, with better than 4.5-mil resolution. Speed, however, can be traded for sensitivity since the faster the line rate, the longer the time during which the diodes can integrate photocurrent.

Dynamic range is in excess of 100:1. Operating voltages are all less than 20 volts. Power dissipation is 4 milliwatts. The RL1872F is housed in a 22-pin gold/ceramic dual in-line package 0.4 in. wide and 1.6 in. long and is sealed with an optically polished quartz crystal.

Fairchild's sensor, the CCD 121 (below), is a charge-coupled device, in which isolated packets of charge are transported from one position in the semiconductor to the next by sequential clocking of an array of MOS gates. Though it has fewer elements than the Reticon device, it also is aimed at facsimile readers and provides a 200-line-per-in. resolution across an 8½-in. page. In addition to a row of 1,728 sensing elements, the CCD 121 includes a charge detector/amplifier and a compensation output amplifier. Two-phase analog shift registers feed the input of the charge detector, resulting in sequential reading of the elements.

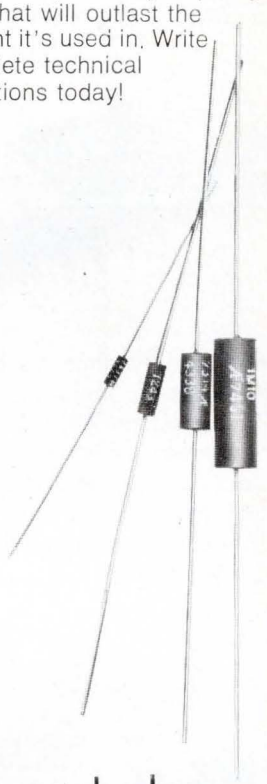
Fabricated with standard silicon IC technology, the CCD 121 also uses Fairchild's Isoplanar buried-channel technology to provide high efficiency and fidelity. All the operating voltages on the device are less than 20 V. Dynamic range is 170:1 typical at 1 megahertz. Power dissipation is typically 100 mW.

The device is packaged in a 24-lead dual in-line package, 0.52 in.



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Circle 183 on reader service card

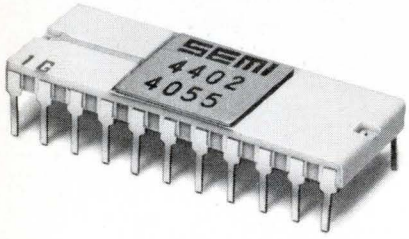
SHIFT INTO HIGH PERFORMANCE WITH A 4K STATIC RAM

FULLY STATIC: The SEMI 4402 is a fully static 4K RAM. That's important. For one thing, it means you can now design a 250 nsec MOS memory system around a 4K device without worrying about refresh or charge pump circuitry. For another, static RAMS are inherently less susceptible to soft bit error problems than comparable dynamic devices.



350 NANOSECOND CYCLE: The SEMI 4402 4K static RAM has a *complete cycle time* of just 350 nsec and 200 nsec maximum access time. That makes it the fastest 4K static RAM in production. Now you can design a truly high performance MOS memory around a static 4K device.

AVAILABLE NOW: The SEMI 4402 4K static RAM is here now. We're already delivering it to customers at the memory system level. And it is second sourced by a major supplier of MOS devices.



LOW POWER: The SEMI 4402 4K static RAM has similar power levels to comparable dynamic devices. However, power conservation is achieved by the Chip Select Input, which causes the 4402 to enter a low power standby state whenever it is unselected. Normal V_{DD} is 12 Vdc, but V_{DD} can also be reduced to 5 volts without risking loss of stored data. And the 4402's differential output results in inherently high noise immunity memory systems.

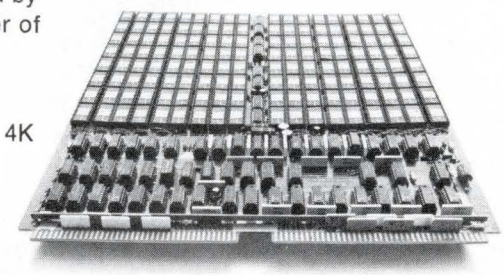
PERFORMANCE TESTED: Like all SEMI NMOS components, the 4402 4K static RAM must meet our own tough test standards, since we use it in our memory systems — for example the MICRORAM 3400N. With our reputation riding on its performance, you may be sure the acceptance standards are high indeed. In fact we 100% ac and dc test our components twice — at wafer and again in the package.

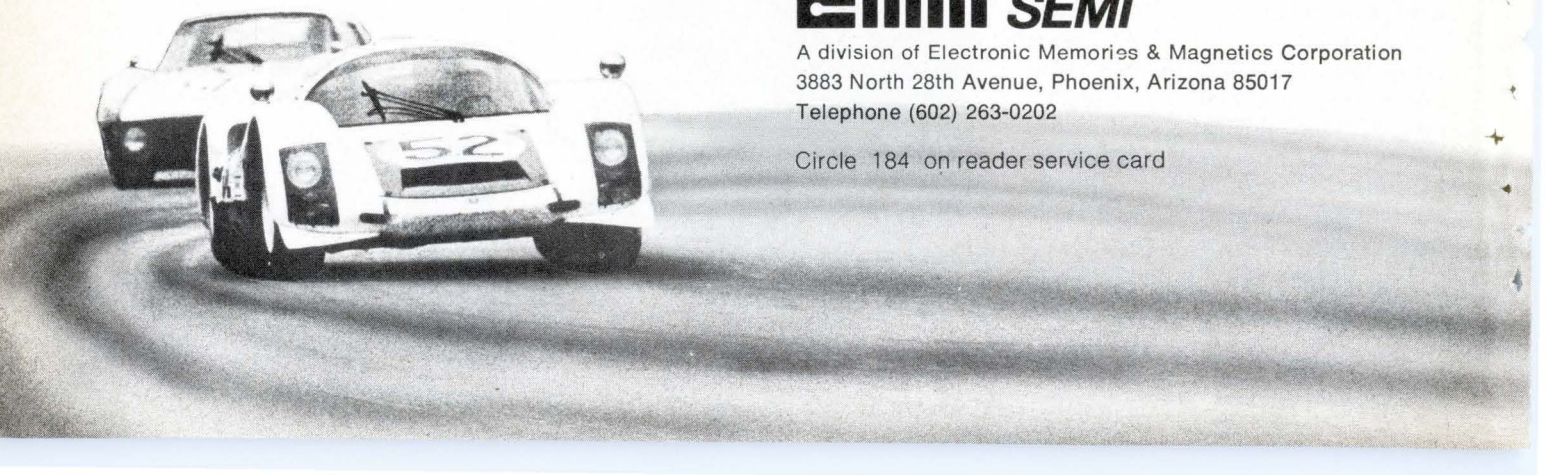
Part No.	Bit Org.	Access Time
RAMS		
SEMI-1801	1024 x 1	90 nsec.
SEMI-1802	1024 x 1	70 nsec.
SEMI RA-3-4256	256 x 4	1 usec.
SEMI RA-3-4256B	256 x 4	1 usec.
ROMS		
SEMI RO-3-4096	512 x 8	500 nsec.
SEMI RO-3-5120	512 x 10	500 nsec.
SEMI RO-3-16384	4096 x 4	1.0 usec.

More new products to come . . . additional 4K static RAMs, ROMs.

MODEL SELECTION: In addition to the 4402, EMM SEMI offers you a complete line of static NMOS RAM and ROM components to meet your design needs. Make your selection from the adjacent chart.

PROVEN TRACK RECORD: At EMM we've been making memory components and systems since 1961. Unlike memory suppliers who market components only, all EMM components are all performance proven in our own systems. When you buy from EMM, you get the benefit of the unusually high acceptance standards we impose on ourselves, as well as our years of experience in meeting the needs of the memory marketplace. If you'd like further information about any of the products featured here, or any other EMM components or systems, contact your local EMM office today.





EMM SEMI

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Telephone (602) 263-0202

Circle 184 on reader service card

wide and 1.250 in. long, with a glass window and a low-reflectance optical cavity.

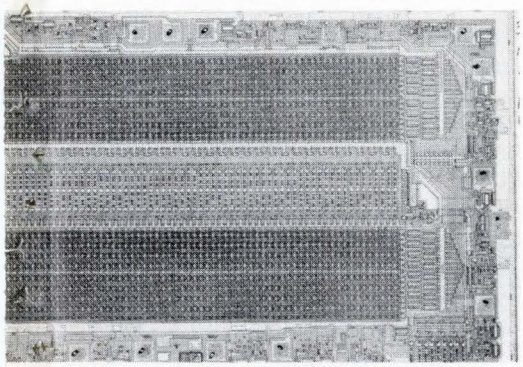
Both the RL-1872F and CCD 121 are available from stock. The Reticon device is priced at $3,800 in prototyping or single quantities and under $100 in large OEM quantities. Pricing on the Fairchild device is not available.

Reticon Corp., 910 Benicia Ave., Sunnyvale, Calif. 94086 [411]

CCD Marketing, Semiconductor Div., Fairchild Camera & Instrument Corp., 4001 Miranda Ave., Palo Alto, Calif. [338]

Intel introduces five Schottky bipolar PROMs

Rounding out what it calls the industry's first complete family of bipolar programable read-only memories and interchangeable metal-mask ROMs, Intel Corp. is introducing five new Schottky bipolar



three-state 2,048- and 4,096-bit PROMs. The new types are:

- The 3624 4,096-bit (512 by 8 bits) high-speed PROM, with eight outputs, four chip-select inputs, nine address inputs, and a worst-case access time of 70 nanoseconds.
- The 3624-4, with the same configuration as the 3624, but a worst-case access time of 90 ns.
- The 3622, a 2,048-bit (512 by 4 bits) high-speed PROM, a 16-pin design with four outputs and chip-select input; it has nine address inputs and a worst-case access time of 70 ns.
- The 3622-4, with the same configuration as the 3622 but an access time of 90 ns.
- The 3622-6, a low-power version of the 3622, which, when not selected, goes into a low-power standby mode with a dissipation of only 120 microwatts per bit, 60% less than when selected. (Active power dissipation is 280 μW per bit, 20% less than the 3622).

With the addition of these five devices, Intel's family now contains 28 types, providing open-collector, three-state, low-power, high-speed and 1-, 2-, and 4-kilobit configurations in both the 3600 PROM series and the interchangeable 3200 Schottky bipolar ROM series.

All operate at DTL/TTL levels from a standard +5-volt power supply. Worst-case speeds are guaranteed from 0 to 75°C with a ±5% power-supply tolerance. Like earlier members of the 3600 series, all five devices have polycrystalline silicon fuses immune to shorting, regrowth and opening problems. Typical programing rate with an automatic pulse programer is about 1 millisecond per bit. A novel feature of the family in general is that the 2- and 4-kilobit types are as fast as the basic 3601 1,024-bit type, which also operates at 70 ns worst-case.

The new three-state PROMs are directly interchangeable with Intel's 3322 and 3324A three-state metal-mask ROM families.

In quantities of 100 to 999, the 3622 is priced at $20.30 each; the 3622-4, $16.25; the 3622-6, $24.40; the 3624, $40.60; and the 3624-4, $32.50.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051 [412]

Counters operate in gigahertz range

Two new counters in Motorola's MECL III family have a typical toggle frequency of 1.2 gigahertz. They are a divide-by-10 counter, the type MC1696, and a divide-by-4 unit, the MC1699. The divide-by-10 circuit, expected to be extensively used in instrumentation, also has binary-coded-decimal outputs. Clock-enable and reset functions are

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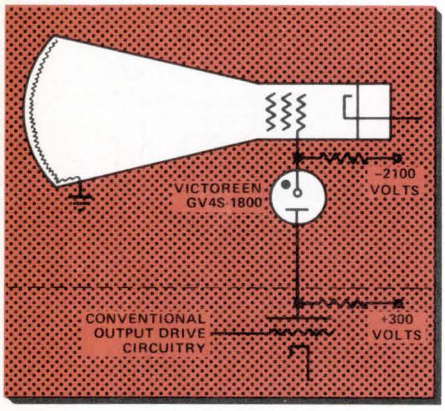
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12621 Chadron Avenue
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Problem solving... with Victoreen High Voltage Technology

1 UNORTHODOX CRT DRIVE

How did we meet ever-expanding requirements for increased bandwidth and lower power consumption, coupled with the availability of high-voltage zener-type diodes (Victoreen Corotrons)? With an unorthodox drive scheme for CRT's.

Instead of supplying the CRT anode with very high voltage, we ground the anode and supply a drive signal, riding at approximately —1800 volts, to the grid. The advantages? Being direct-coupled there are no reactive components to limit high-end frequency response or cause roll-off at the low end.



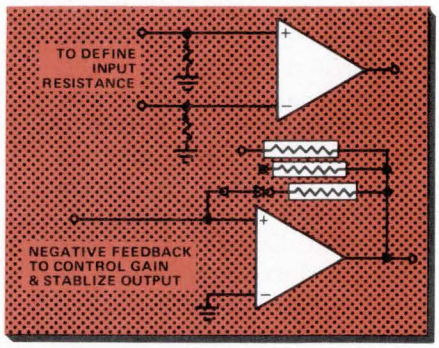
Even though the Corotron operates in the corona mode of discharge, it has no voltage jumps or jitters. Corotrons are not tied to "natural" operating voltages and are adjustable in manufacture from 350 to 30,000 volts.

2 FROG MUSCLES TO BRAIN WAVES

Colleges and universities, medical research laboratories and R&D firms need amplification of low level signals. Such signals are derived from frog-muscle experiments, brain-wave measurements, cardiac research, avalanche-breakdown, currents in ionization chambers as well as from a range of constant-current sources.

Victoreen MINI-MOX resistors are used widely to modify op-amp characteristics to: 1. Stabilize output and eliminate oscillation. 2. Define gain so measurements can be quantified. 3. Restrict bandwidth to the region of specific interest.

They typically have a voltage coefficient of —5 ppm/volt, full-load drift of less than 2% in 1000 hours, temperature coefficient of 100

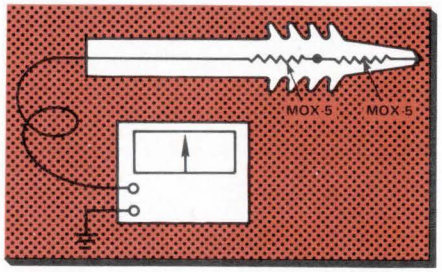


ppm, and a Quantech noise of less than 1.5 V/volt at 20M ohms. They are available in values from 100K to 10,000M ohms in 1, 2, 5 and 10% tolerances.

3 A PROBE FOR HIGH POTENTIAL

Two Victoreen MAXI-MOX resistors used in series can serve as a probe in radar circuitry capable of measuring voltages up to 60,000 volts. The probe, compatible with a number of voltmeters of different manufacture, has both short- and long-term stability. Short-term stability assures negligible drift and fluctuation during measurement, while long-term stability maintains the original calibration accuracy of the probe.

Each MOX-5 resistor used in the probe has a maximum operating voltage of 37,500 volts with a power rating of 12½ watts. The voltage coefficient is 1 ppm/volt over the complete voltage range of the MOX-5, while the temperature coefficient is better than 300 ppm for —55° to 125°C.



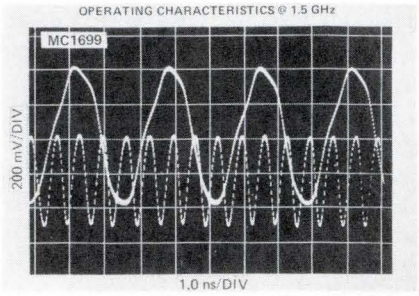
MAXI-MOX resistors have full-load drift less than 1% in 2000 hours of operation, and are available in tolerances of 1, 2, and 5% in values from 10K to 2,500M ohms. A silicone varnish conformal coating provides environmental protection while allowing a maximum hot-spot temperature of 220°C.

Victoreen Instrument Division
of VLN Corp.
10101 Woodland Avenue
Cleveland, Ohio 44104

VICTOREEN

Circle 186 on reader service card

New products

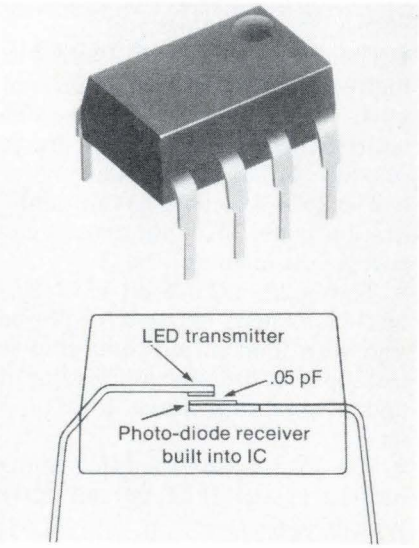


also available. The 1699 divide-by-4 counter is intended for digital television tuners and for prescaler applications. In lots of 100 to 999, the 1696 is priced at $89 each, and the 1699 at $39. Both are available from stock, housed in 16-pin ceramic packages.

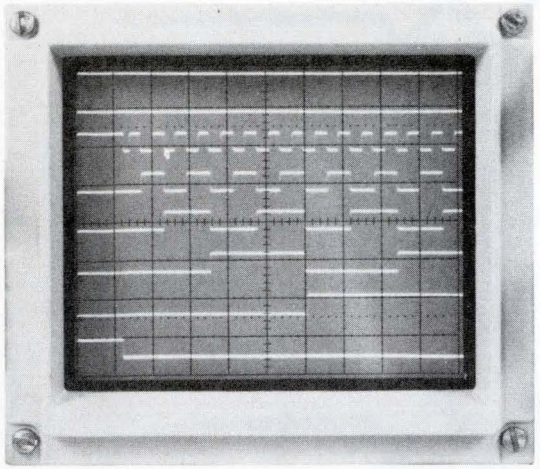
Technical Information Center, Motorola Inc., Semiconductor Products Div., P. O. Box 20924, Phoenix, Ariz. 85036 [413]

5-megabit opto-isolator has noise rejection of 50 dB

An opto-isolator that transmits data at 5 megabits per second also offers a common-mode rejection of 50 decibels, said to be the highest ever achieved by an opto-isolator. The TL-100 uses a light-emitting-diode source that transmits to a photodiode receiver built into an integrated circuit. Capacitive coupling between the transmitter and receiver is only 0.05 picofarad. Maximum propagation delay is 75 nano-



If your bench scope says your ECL logic looks like this...



...you're using the new 100MHz 8100-D Digital Logic Recorder from Biomation.

Introducing the new 100MHz Glitch Fixer: Biomation's 8100-D puts a faster fix on faster glitches.

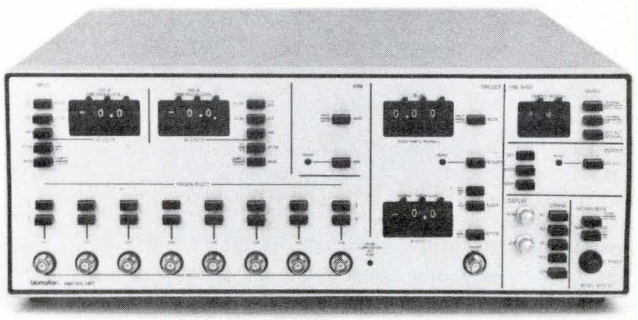
The original Glitch Fixer, Biomation's 810-D, has been helping a lot of engineers study timing relationships of 8-bit signals at speeds up to 10MHz.

But because the world's going faster—with MECL, ECL II, ECL III and Schottky-clamped I^2L parts in your boards—we've built a new digital logic recorder, the 8100-D, with speeds up to *100MHz*.

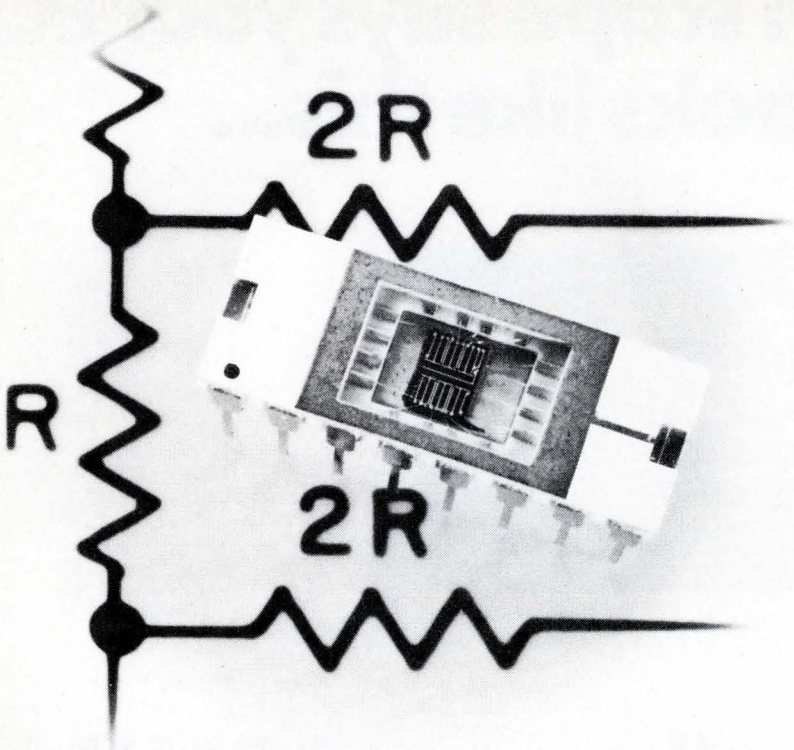
It's the new-and-faster way to turn your ordinary bench scope into a data stream display. It records 8 data channels at once and presents them in the same format you're used to seeing on data sheets.

The 8100-D features built-in combinatory logic setting to help you isolate your problem event *fast*. It has a big memory, too; can store up to 2,048 8-bit data words, including the often critical information that lies *just ahead* of the triggering event. And it also provides digital output for computer analysis or mass storage.

The 8100-D is a piece of diagnostic instrumentation that circuit designers and troubleshooters have been asking us for. We will be glad to send you all the splendid details. Just use the reader service number or get in touch with us directly. Biomation, 10411 Bubb Road, Cupertino, CA 95014. (408) 255-9500. TWX 910 338 0226.



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New products

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Litronix Inc., 19000 Homestead Rd., Cupertino, Calif. 95014 [414]

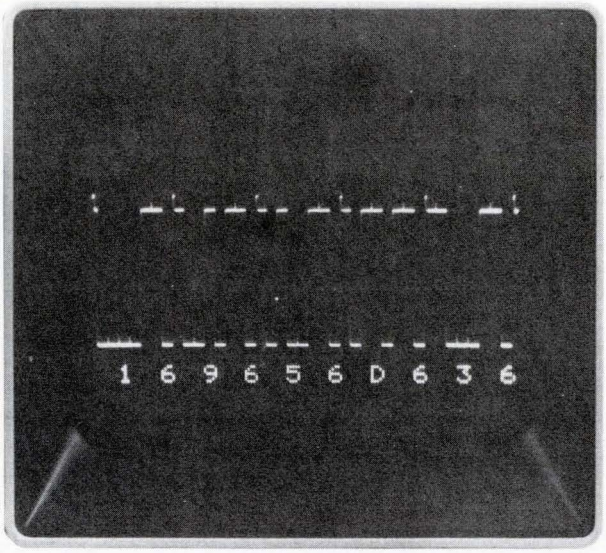
Power transistor puts out 5 watts up to 2 gigahertz

Designed for ship-to-satellite communications between 1636.5 and 1645 megahertz, an rf power transistor designated the 2005BLY is capable of a 5-watt output at frequencies as high as 2 gigahertz. The transistor has gain of 9 decibels and operates from a 28-volt supply. It is a common-base transistor having internal input-matching networks and operates in a Class-C mode. Samples are available from stock, and production quantities are available in 60 to 90 days at prices of $110 to $75 each, depending on quantity.
Communications Devices, Amperex Electronic Corp., Hicksville Div., Hicksville, N.Y. 11802 [415]

IC multiplier/divider needs no external adjustments

Monolithic construction is used to achieve a completely self-contained transconductance multiplier without the need for any external adjustments or output operational amplifier. The models M540J and M540K multiplier/dividers can be used for four-quadrant multiplication or two-quadrant division, as well as squaring or square-rooting. The M540J is specified for a maximum multiplying error of ±2%, and the M540K for 1% maximum error. Small-signal bandwidth is 1 megahertz, and full power output goes to 750 kHz. In quantities of one to nine, the J model is priced at $26 each, and the K type is $36. Each is available in either the hermetic TO-100 metal can or the TO-116 dual in-line package. Delivery time for the multiplier/dividers is two to four weeks.
Intronics Inc., 57 Chapel St., Newton, Mass. 02158 [416]

And now, for debugging serial data,



Biomation brings you the 110-D.

Not just a new product. An entirely new kind of data recorder. From the folks who brought you the Glitch Fixer.

The best way to tell you about the Biomation 110-D's dramatic new way of debugging serial data is to show you the memo from our own engineering staff that sold us on the concept.

Purpose

Designed to monitor, store, and display serial data, either synchronously or asynchronously. Major uses as follows:

1. High speed synchronous data (up to 10MHz)

- Rotating memories (drums, disks, floppy disks).
- Digital tape decks—up to and including high performance 3200 bpi reel-to-reel decks.

110-D will "snapshot" data and display it free of the jitter normally seen when using scope.

- Shift register and delay line memories (MOS shift registers, magnetostrictive delay lines, glass delay lines, etc. such as found in CRT-type data communications terminals and other video-refresh applications.

110-D will snapshot changing data patterns and allow stored analysis, otherwise impossible with scope.

2. Low speed synchronous data

110-D utilizes static RAMs to prevent data loss at low speeds.

- Synchronous modem channels—data between modem and terminal, between modem and computer front-end, etc. Includes Bell 201-type modems and other proprietary synchronous modems.

Using a scope has same problems as above: changing data patterns and channel jitter makes analysis difficult or impossible.

3. Low speed asynchronous data

- Asynchronous modem channels—Bell 103- and 202-type modems and equivalent units from independent suppliers. **110-D has switchable internal clock for sampling data at normal data baud rates.** Also has start-bit validation logic, for "framing" the data in start-stop data.
- RS232 data channels—includes nearly all computer terminals, both video and hard-copy. Teletype KSR-33 and Dataspeed 40 terminal are typical examples.

Asynchronous data is not only changing and jittering, but is coming in asynchronous bursts. The 110-D will time-compress the data to permit whole message groups to be easily observed.

Data from low speed computer peripherals—printers, card readers, card punches, paper-tape readers, etc. are often transmitted serially between them and the host main-frame. The 110-D is useful in developing and trouble-shooting these peripherals.

There isn't enough room on this page to give you the whole story. Please call or write us for all the technical data and for a "hands-on" demonstration of a whole new solution to serial data problems. Biomation, 10411 Bubb Road, Cupertino, CA 95014. (408) 255-9500. TWX 910 338 0226.



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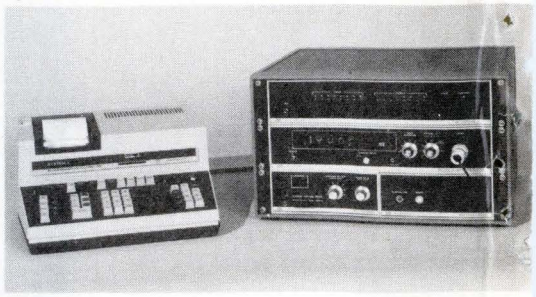
Instruments

Calculator runs test systems

Keithley offers aid in interfacing instruments from other manufacturers

Calculator-controlled instrument systems can, of course, save time and money by eliminating manual operations in repetitive or complex measurements. One drawback, though, is that they often require that all the instruments within the system be purchased from the same vendor, or that costly additional interface hardware be supplied by the user.

Now Keithley Instruments Inc. is offering a series of calculator-based data-acquisition, control, and measurement systems that can be connected to other manufacturers' instruments when the application requires them. The series of plug-to-plug compatible instruments comes complete with interfaces, other hardware, and software.



The heart of the System 1 family is a programable calculator with a paper-tape printer. In its most sophisticated form, the System 1 can include and control up to six instruments plus 16 10-channel analog-input scanners. The calculator has a 512-word memory expandable to 4,096 words, and magnetic-card storage is standard.

System price is a function of complexity and the instruments included. For a simple system, however, consisting of the calculator, a control unit, a microvolt-sensitive digital multimeter, a 10-channel low-voltage scanner, and the required interfacing, software, and system documentation, the price starts at about $6,700.

Communicating with any instrument in the system is simplified by single-keystroke commands for such functions as read, output, and wait. The wait command programs a time delay, which may be used to allow signals to settle or to program the system to take readings on a cyclic basis—every two hours, for example.

For the user who does not want to

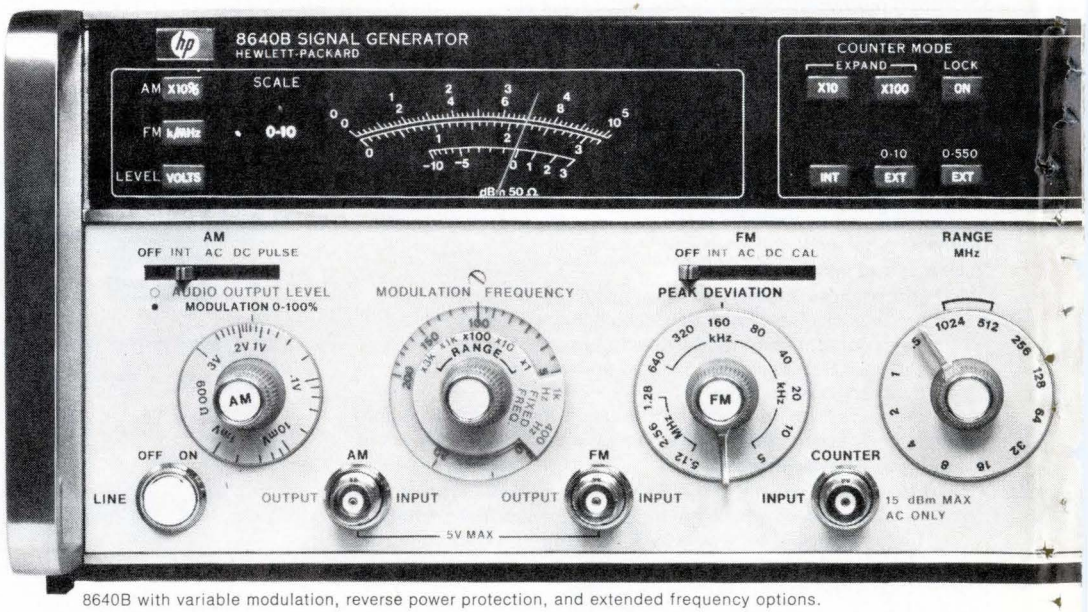
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Simultaneous AM and FM possible. External pulse.



8640B with variable modulation, reverse power protection, and extended frequency options.

Variable modulation oscillator option — 20 Hz to 600 KHz; use for internal AM or FM; also available at front panel.

Built-in counter — measures external signals to 550 MHz.

Spectral purity — high Q, cavity-tuned solid-state oscillator yields excellent low noise performance needed for new stringent receiver testing. SSB noise 130 dB/Hz down at 20 KHz offset.

04503

get heavily involved in setting up the system, custom applications programs are available.

Delivery time for System 1 is 90 to 120 days.

Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, Ohio 44139 [351]

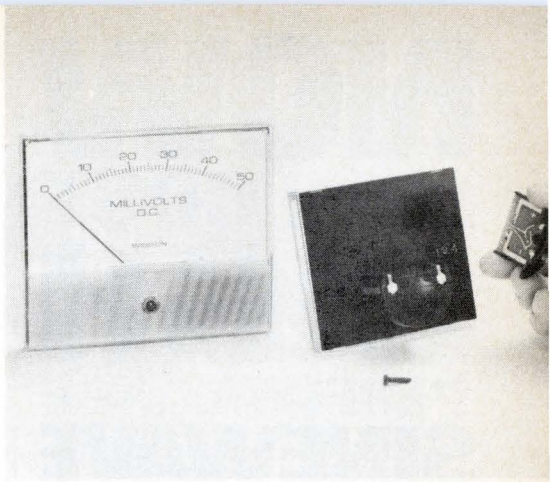
Analog panel meters are low in price and bulk

In many applications, analog panel meters have the advantage over digital units because they are less expensive and take up less space behind the panel. The Mustang series from Weston Instruments Inc. is designed to increase this advantage by offering a lower price and even less behind-panel bulge than earlier Weston units.

The company's standard 2000 series panel meters are priced between $14 and $30 in large quantities and have barrels measuring about 2¾ inches in diameter on larger instruments. By comparison, the Mustang series offers prices that are about 50% lower, and barrels that measure less than 1½ inches across.

The meters are available in 1½-, 2½-, 3½- and 4½-inch sizes for front or rear mounting and in a 6-inch size for front mounting. Suspension options are taut-band or pivot-and-jewel, with microammeter, milliammeter, ammeter, millivoltmeter, and voltmeter scales for dc measurements and a rectifier-type voltmeter style for ac use.

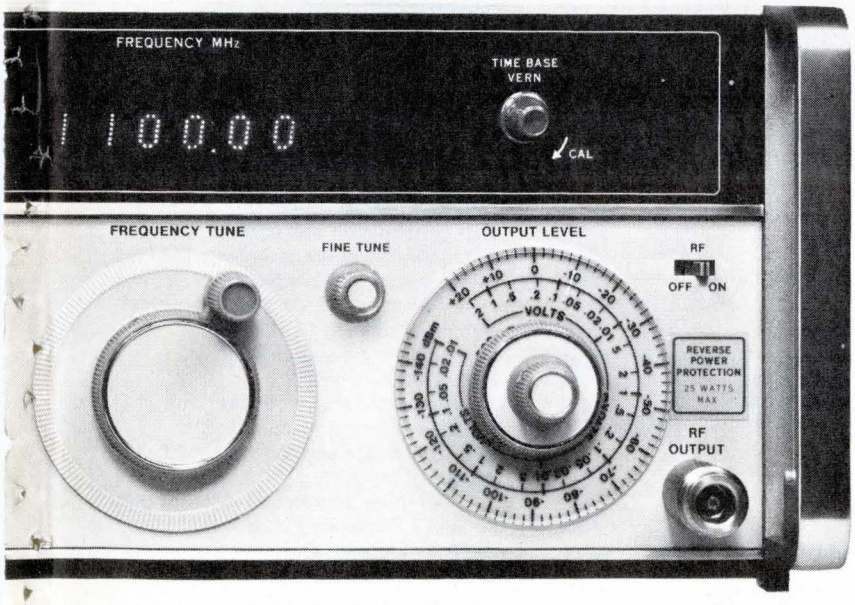
As shown at right in photo, modular, add-on packages can be provided for shunts, diodes, and large resistors to obtain non-standard ranges without exposing the meter movement to dust and other contaminants. A plastic locking-ring mechanism can be used to secure front-panel-mounted units without additional hardware.



Simplified assembly of the units, eliminating some of the adjustments necessary on older models, accounts in part for the lower prices. In addition, less costly materials, such as a plastic instead of metal pointer and a hot-stamped aluminum instead of chromium optional mirror, are used, and case parts are thinner. Also, while accuracy is still specified as within ±2% of full scale on dc and

Wide frequency range — wide application range — from AM & FM broadcast through HF, VHF, mobile FM, and avionics receiver test, 450 KHz to 550 MHz. (optional extension to 1100 MHz)

High resolution tuning and display — easy to tune and phase lock carrier to desired setting on 6-digit LED readout; resolution of 100 Hz at 500 MHz.



Wide dynamic range for complete testing — high level (+19 dBm) for spurious response tests, down to −145 dBm for tests at <0.03 μV on shielded receivers. Reverse power option protects against damage from accidental transceiver triggering to 25W.

Phase-lock frequency stability — long term stability locked to crystal time base is <5x10 -8/Hr. Spectral purity and FM capability are preserved during phase-lock.

These are just a few of the reasons why the 8640 does today's job so well, and gives you built-in assurance that you won't run out of capability as tomorrow's demands come along. Price $5900 (w/o options); $6650 (1100 MHz). Also available with avionics option specially adapted for testing ILS (marker, glide slope, localizer), VHF communication and VOR receivers.

For more information on the 8640B and all of its options, call or write your nearest HP sales office.

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Weston Instruments, Inc., 614 Frelinghuysen Ave., Newark, N.J. 07114 [352]

Programable supplies offer digital or analog readout

Heath Co. has, over the past few years, expanded from the consumer product and service-instrument kit businesses into the industrial market with low-cost bench-type gear. Now the firm is extending its base still further with a line of programable power supplies for systems, laboratory or service use.

The supplies, with outputs up to



7.5 volts at 10 amperes, 15 V at 5 A, 30 V at 3 A, or 60 V at 1.5 A, are available with either analog or digital readout of voltage or current. The analog readout units are priced at $255, and the digital models at $340. Kit versions are $169.95 and $219.95, respectively.

Line or load regulation of voltage is ±0.05% +1mV, current ±0.1% +1mA. Other features include constant-voltage or constant-current operation, remote sensing, and series or parallel connection facilities for higher output.

Heath Co., Benton Harbor, Mich. 49022 [353]

Three-digit multimeter is priced at $99.95

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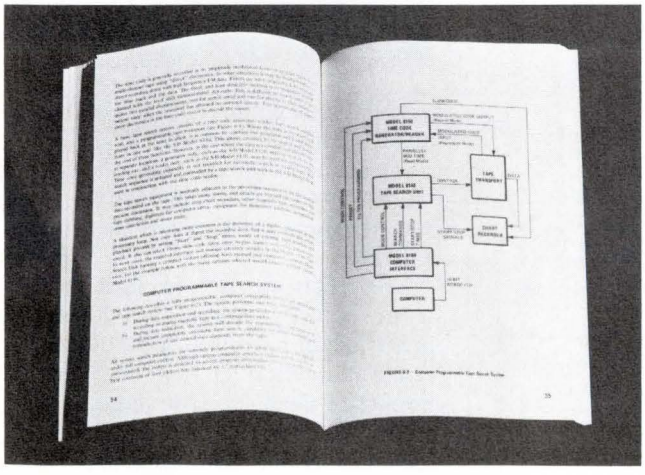
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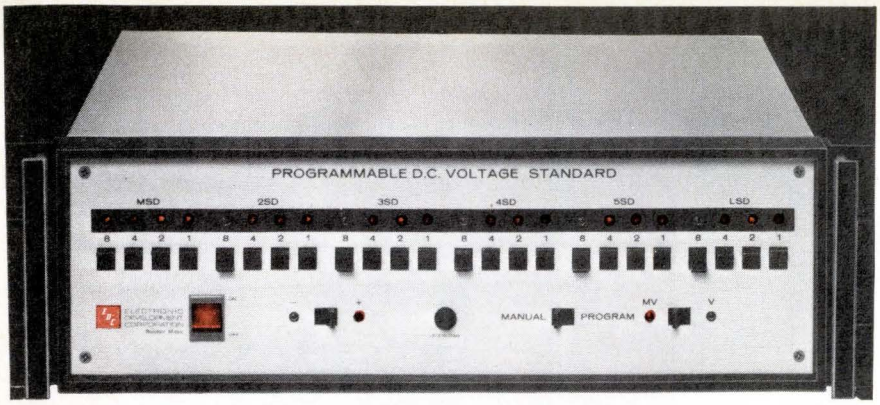


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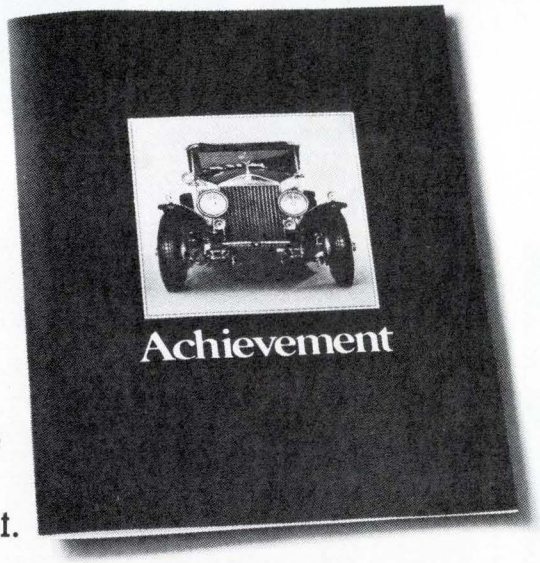
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Specified typical accuracy for the



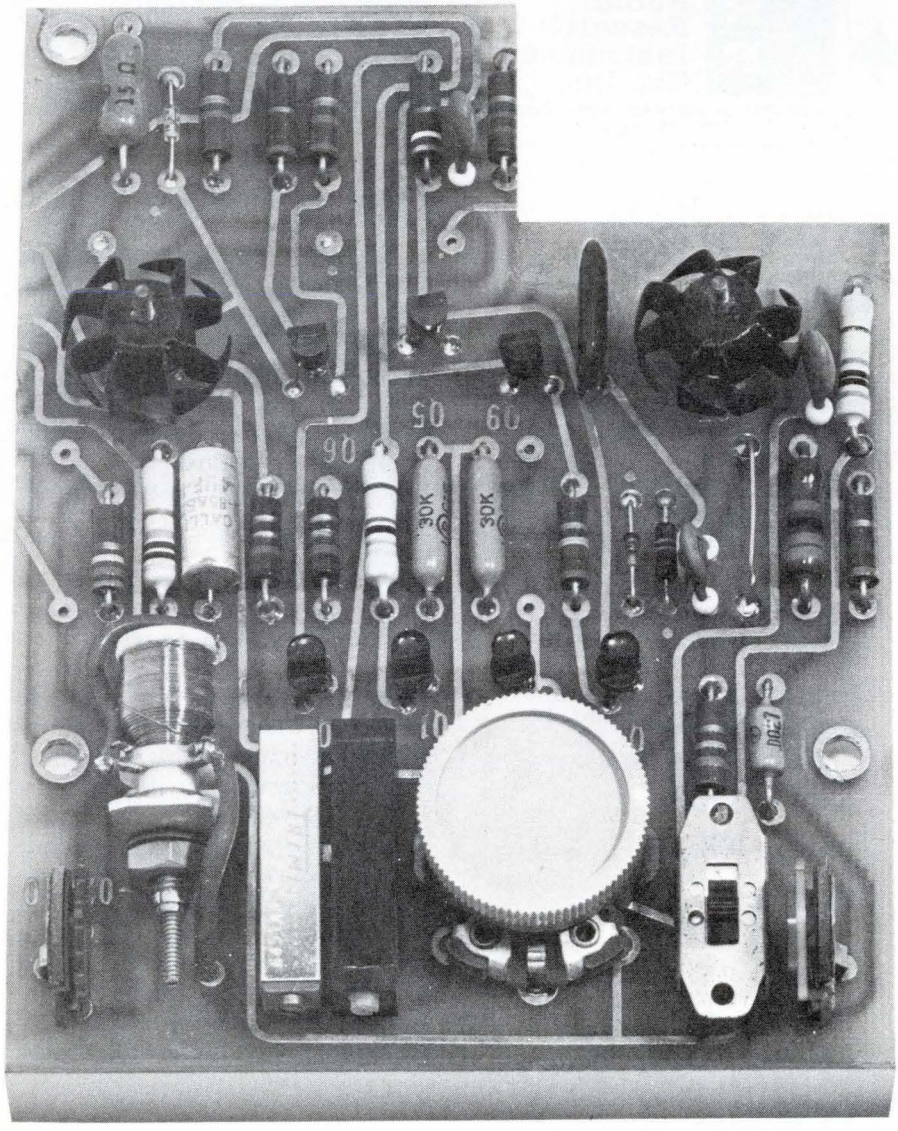
model 280 is within ±1% of full scale on dc volts and within ±2% of full scale on ac volts and ohms, except on the 10-megohm range where typical accuracy is specified as within ±2.5%.

The instrument provides automatic polarity, automatic decimal-point location, and automatic overrange indication. It is housed in an impact-resistant plastic case measuring less than 4½ by 6½ by 2 inches, and operates from four "C" cells.

B&K Precision Division, Dynascan Corp., 1801 W. Belle Plaine Ave., Chicago, Ill. 60613 [354]

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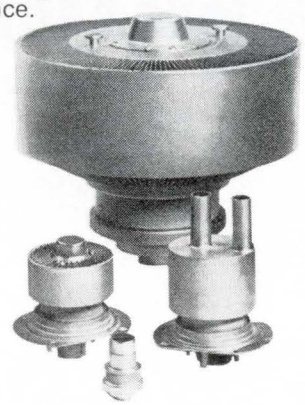
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Kester Solder Div. of Litton Industries, 4201 Wrightwood Ave., Chicago, Ill. 60639, Attn: Mack Haraburd [476]

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Aremco Products Inc., P. O. Box 429, Ossining, N. Y. 10562 [477]

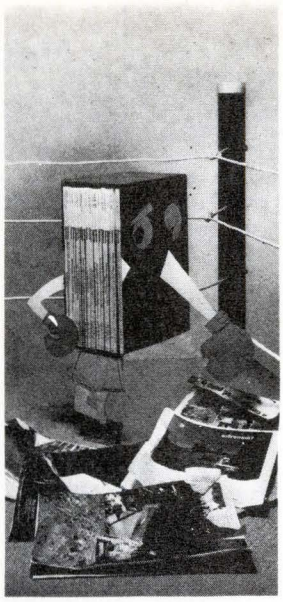
Thick-film resistor paste formula 850-011 yields films with a resistivity of 10 ohms per square and temperature coefficients of 100 ppm/°C or less. A data sheet, designated Bulletin R-850-11, which emphasizes the effect of 96% alumina substrates from different suppliers on the thick-film resistor is available from the manufacturer.
Thick Film Systems Inc., 324 Palm Ave., Santa Barbara, Calif. 93101 [478]

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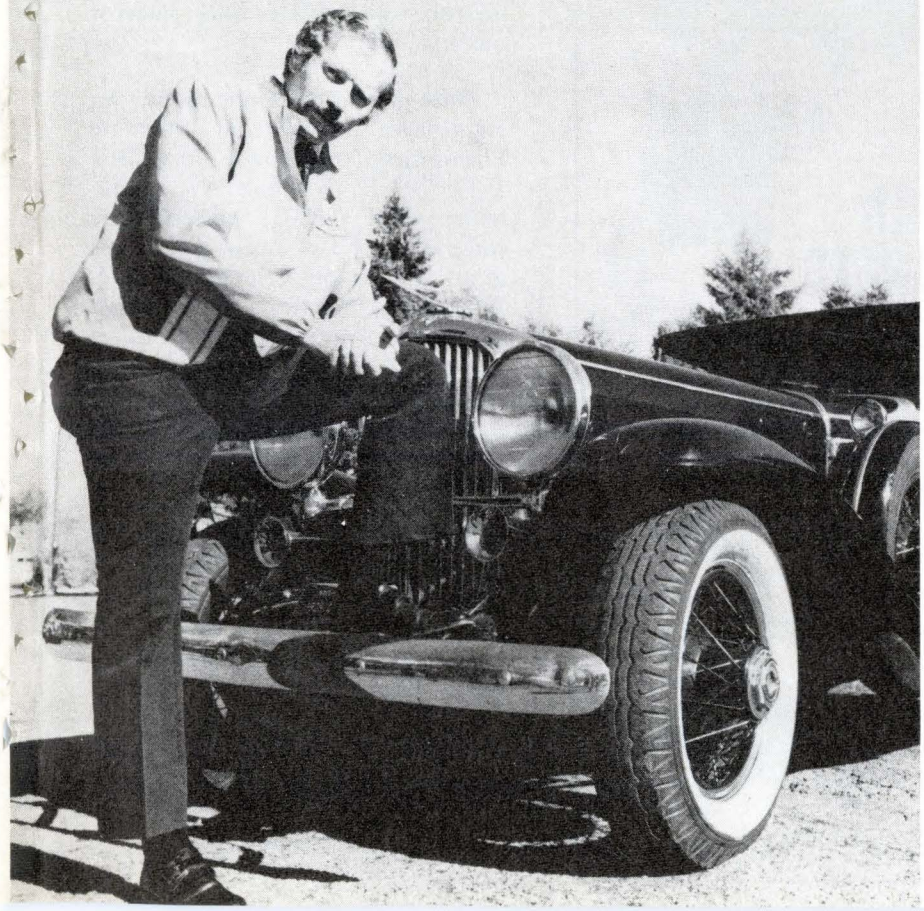
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New literature

Eastern European market. A 282-page report on the size and nature of the 1975 Eastern European electronic equipment and component market sells for $35 and is available from Fred Glynn/Marketing Research, 2200 Sacramento St., Suite 1206, San Francisco, Calif. 94115. The report gives forecasts for 47 types of components and 76 types of equipment for each of the nine Eastern European countries. Also included are information on their trade practices, names and addresses of their state trading companies, names and addresses of their commercial missions in the U. S., major market opportunities, names of the major electronics manufacturers in Eastern Europe, maps, and travel information. Circle 421 on reader service card.

Thick-film substrates. A five-page bulletin, put out by Accumet Engineering Corp., 25 Broad St., Hudson, Mass. 01749, describes the effect that the surface quality of the ceramic substrate has on the quality of the final thick-film circuit. Included are such aspects as active-device bonding, fine-line printing, conductor uniformity, and resistor quality. [422]

Pulse-generator applications. An eight-page catalog from Interstate Electronics Corp., Dept. 7000, Box 3117, 707 E. Vermont Ave., Anaheim, Calif. 92803, presents the company's line of pulse generators in an applications-oriented fashion. The catalog includes a shopping list of features that may prove useful in evaluating pulsers made by other manufacturers as well. [423]

Fractional horsepower gearmotors. The latest issue of Bodine's Motorgram (Vol. 54, No. 5) discusses applications, load conditions, and service factors for fractional horsepower gearmotors. Topics include variable speed/torque loads, shock loads, overhung loads, thrust loads, and others. The Motorgram is available from Bodine Electric Co., 2500 W. Bradley Place, Chicago, Ill. 60618 [424]

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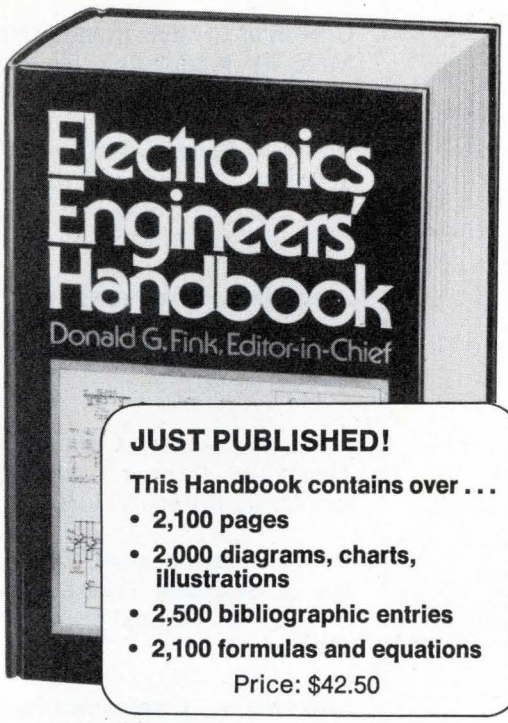
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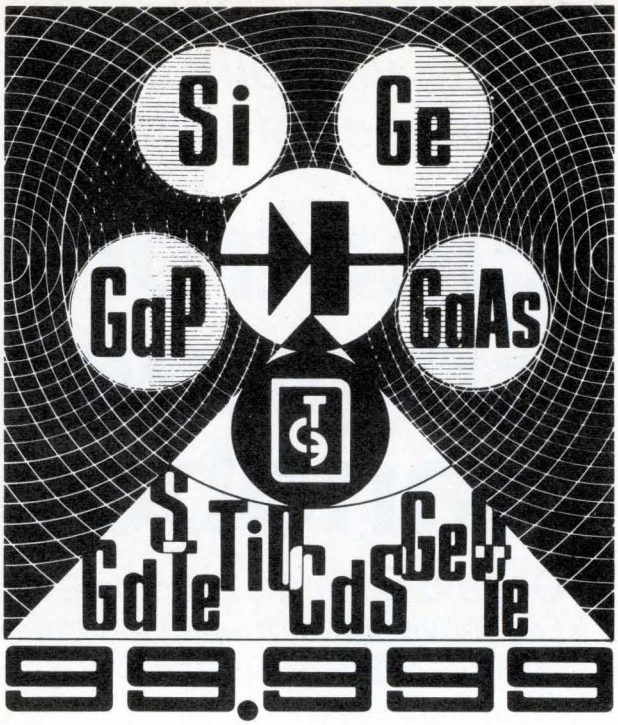
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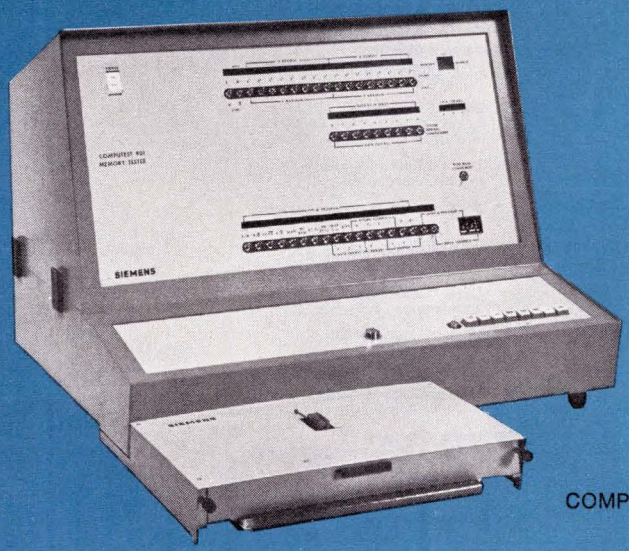
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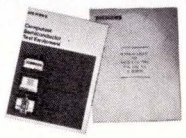
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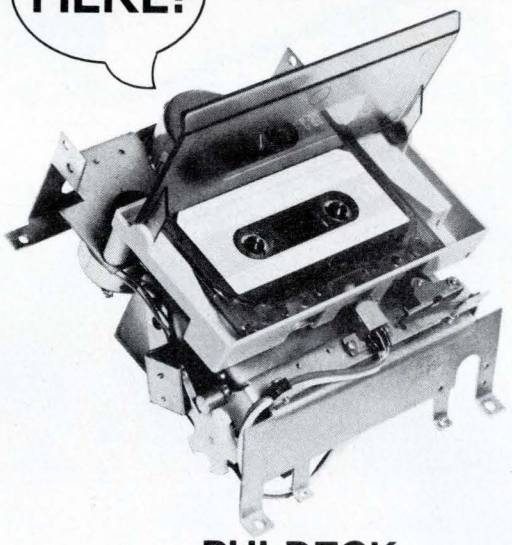
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2. Data recording/logging/storage
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With Features Of:
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- Completely programmable-Logic
- No tape coasting
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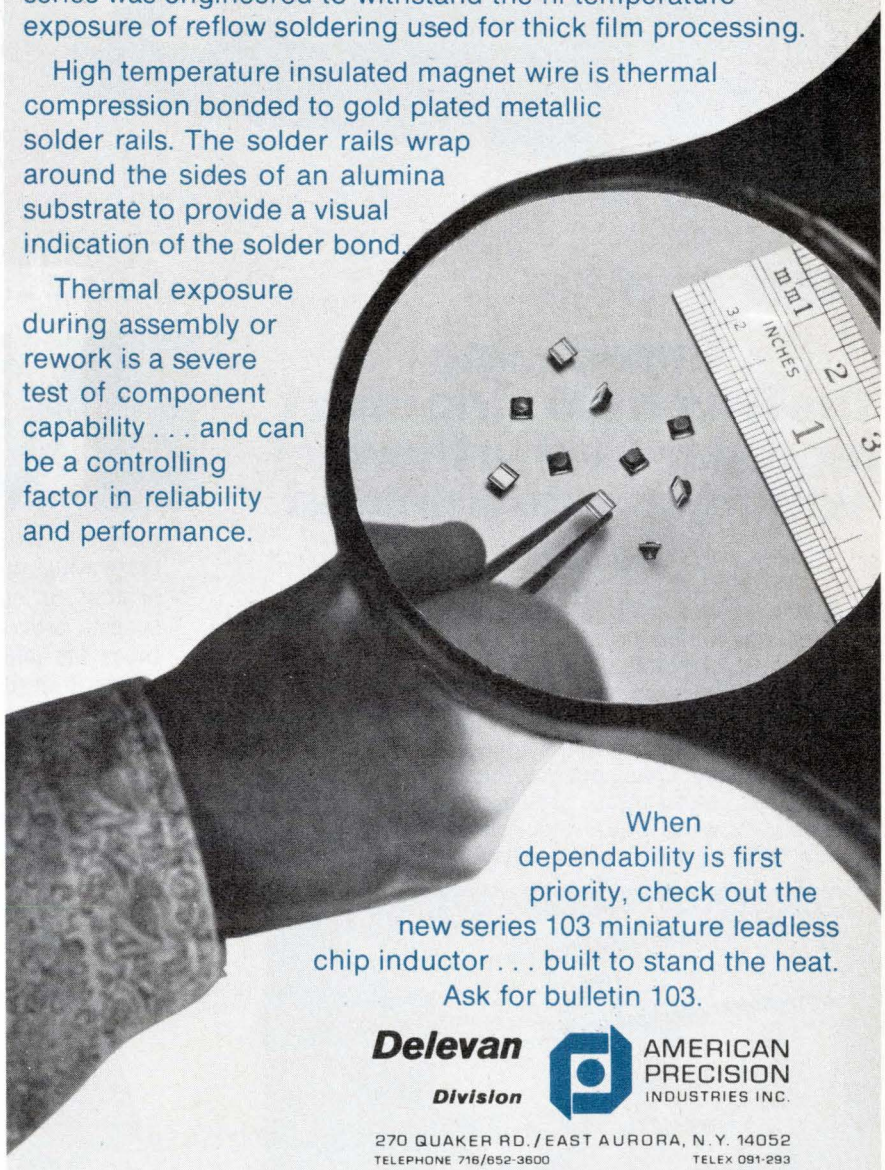
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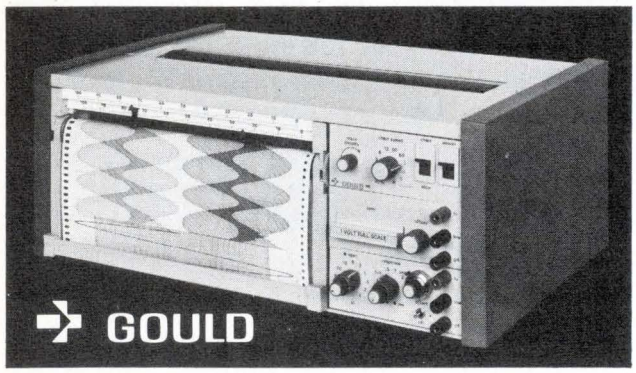
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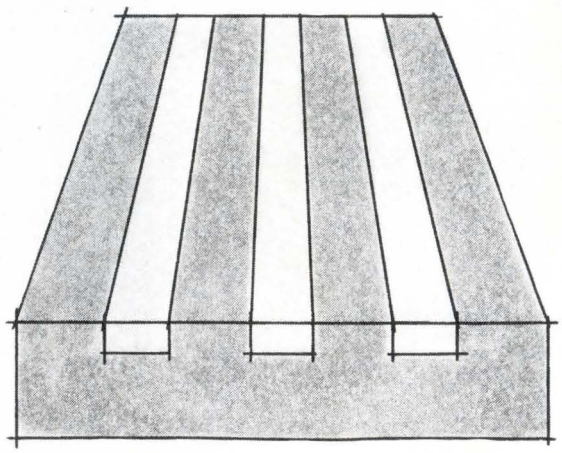
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